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December, 1986

STUDIES OF RADIO-COLLARED CARIBOU IN THE SPATSIZI WILDERNESS PARK AREA, BRITISH COLUMBIA, 1980-1984

David F. Hatler

Spatsizi Association for Biological Research
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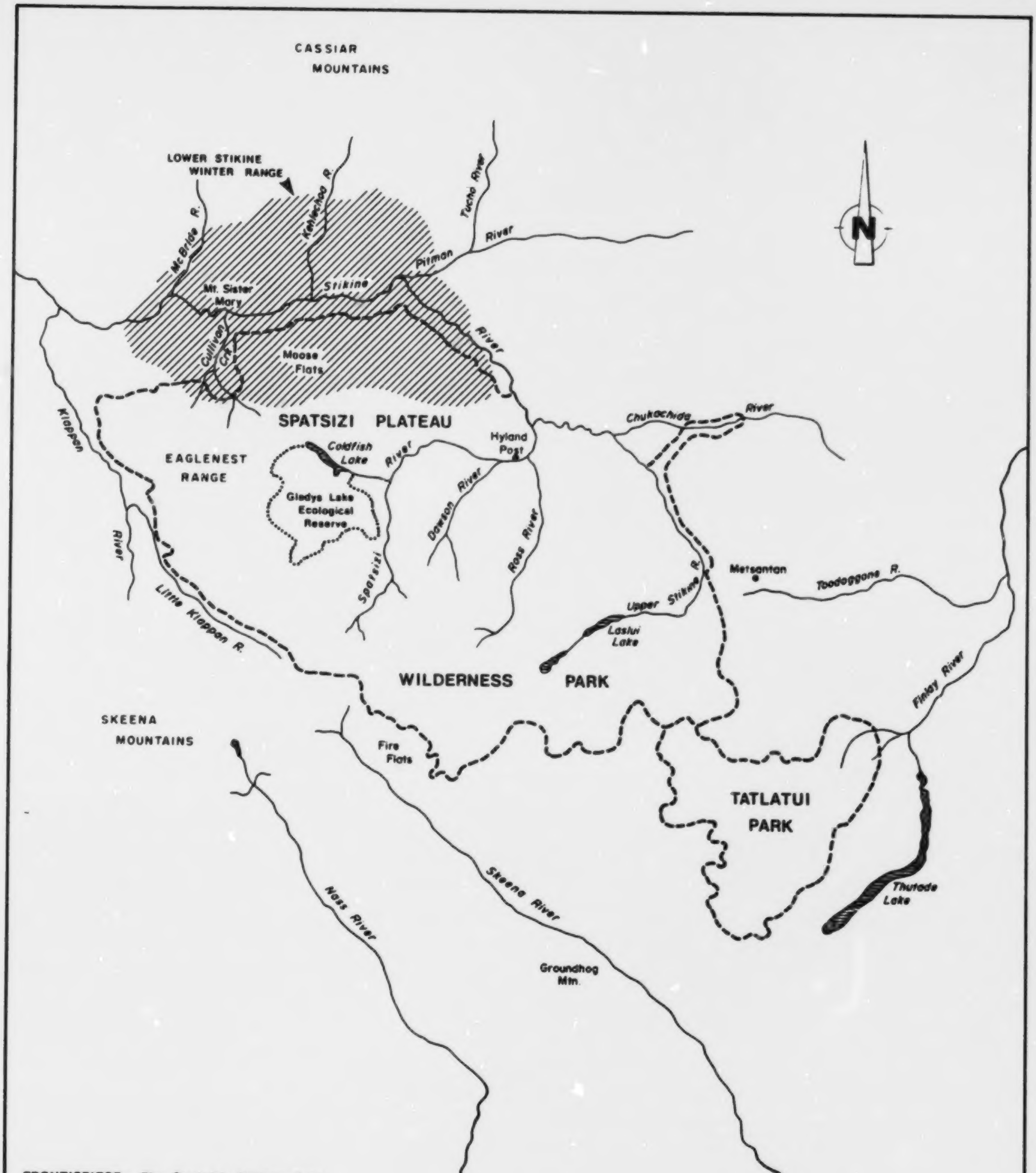
CASSIAR MOUNTAINS
LOWER STIKINE WINTER RANGE
McBride R.
Kehlechoa R.
Tucho River
Pitman River
N
Stikine
Mt. Sister Mary
Cullivan Cr.
Moose Flats
River
SPATSIZI PLATEAU
Klappan River
EAGLENEST RANGE
Coldfish Lake
River
Hyland Post
Chukachida River
Gladys Lake Ecological Reserve
Dawson River
Ross River
Spatsizi
Little Klappan R.
Metsantan
Toodoggone R.
Upper Stikine R.
Laslui Lake
WILDERNESS PARK
SKEENA MOUNTAINS
Fire Flats
Finlay River
TATLATUI PARK
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STUDIES OF RADIO-COLLARED CARIBOU IN THE SPATSIZI WILDERNESS PARK AREA, BRITISH COLUMBIA,

1980 - 1984

By

David F. Hatler

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DEDICATION

Mel Melissen piloted all but one of 35 radio-tracking flights between March 1981 and July 1983. During that time he became a key member of the research team, keenly interested in the project, and contributing much more than just a pilot service. He understood radio transmitter signals better than the biologist he accompanied, and it was he who pioneered the tracking techniques which we are still using to find the animals in that vast and rugged wilderness which he knew and loved so well. He also knew the collared caribou individually, and had his favorites--particularly chronic traveller B18, which he nicknamed "Juliet". Juliet is still with us, but Mel is gone, apparently trapped by weather on a flight through the towering Coast Mountains in September 1983. This report is dedicated to his memory.

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EXECUTIVE SUMMARY

This is a report on a continuing radio-tracking study of caribou in the Spatsizi Wilderness Park area of northern British Columbia. Field activities during the period, late October 1980 through November 1984, included two major capture expeditions, four aerial census surveys in rut concentration areas, and 59 radio-tracking flights. The major topics addressed here relate to the general life history of caribou in the area, including the consideration of seasonal movements, distribution and habitat use, aggregation patterns, aspects of population dynamics, scheduling of events in the annual cycle, and group distinctions.

Results and discussion are highlighted in point form in following pages:

-The study period included two severe and two mild winters relative to long-term local normals for snowfall and snow accumulation; based on patterns of snow melt and phenology, the study included one early and two late springs; the summers were generally wetter than normal, and that has been the pattern in the area since about 1975.

-Among the collared animals of known age, females averaged 8.5 years, and 9 of 16 were 10 years old or older. Both sexes averaged older than samples from most other North American caribou studies, possibly indicating poor past recruitment, good adult survival, or some kind of sampling bias in the Spatsizi area.

-The Spatsizi caribou are larger than barren ground caribou and some other woodland forms, but do not appear to differ significantly in size from those at similar or more southerly latitudes in Alberta.

-Antlers of Spatsizi males peak in size and development between the ages of 5 and 7, and begin to regress thereafter, while those of females increase in size to at least 9 years and may not start regressing until about age 12.

-A total of 54 caribou, 38 females and 16 males, were captured and radio-collared during the study although early problems, especially poor collar retention by males, reduced the sample of animals with 5 or more satisfactory locations to 39. That sample collectively provided 851 animal months of telemetry signal transmission and 840 satisfactory animal locations; 84% of both involved females.

-The total and annual ranges of individual caribou varied greatly during the study period. The most important factor contributing to differences between individuals were differences in their seasonal range affinities; the smallest ranges were those of animals that moved only short distances from the winter range to early summer areas.

-Unlike the case for several other studies, the annual ranges of males in the Spatsizi sample were smaller both in average and extreme values than were those of females.

-Because individuals were found to use different seasonal ranges or the same seasonal range in different ways in different years, observations over one annual cycle cannot serve to fully describe the "traditional" use of a particular area.

-The annual movement patterns of Spatsizi caribou were similar to those recorded previously for the species, including barren ground caribou, in many other areas. The primary area-to-area differences are in the scale of movements, and occasionally in timing.

-Of the abrupt, long-distance movements that caribou make, the most predictable is that made by females in spring, prior to calving. Weather factors may also stimulate long movements. The most dramatic recorded in this study occurred during and after an unusually heavy snowfall in early December 1980.

-There is great individual variability in annual movements, with some animals making regular, predictable movements between widely separated seasonal ranges and others remaining relatively sedentary throughout the year.

-Females with calves moved less than those without from June through mid-October, and then moved farther than those without in late October and November.

-The collared animals were most dispersed in June, at calving time, after which they began to concentrate. The animals were most concentrated in early winter, and they then dispersed again somewhat in winter.

-The winter distribution varied with snow conditions, but always involved the bulk of the animals in northern portions of the study area, including numbers outside Spatsizi Park.

-Areas used in summer included uplands in all directions and up to at least 125 km from the winter range, but with the longest movements and most individuals to the south.

-The three rut concentration areas that had been identified in previous studies were regularly and predictably occupied by numbers of caribou in the fall but many animals, particularly females with calves, did not attend those specific areas during the rut.

-Parous females showed a strong homing tendency in their spring migration, some returning over distances up to 100 km to within meters of calving sites used in previous years. Males and barren females also showed a moderate degree of homing to June locations.

-The Spatsizi caribou generally occupied high elevation subalpine and alpine tundra habitats, above 1500 m, in summer and fall, and forested areas below that elevation in winter. The most variable season in that regard was winter, when snow conditions might force animals to higher elevation, windblown areas.

-Following a heavy snowfall in early December 1980, most animals moved to alpine habitat in the northern Eaglenest Range and remained there throughout the winter. A study conducted only in that winter would have drawn erroneous conclusions regarding preferred wintering habitats in the Spatsizi area.

-Almost 85% of all radio-locations were on north or south slopes, of which north was preferred in all seasons. That result differs from those in other areas in which slope selection has been studied, and may be related to local climate patterns, such as wind effects on snow cover at Spatsizi.

-The heaviest use of non-forested lowland habitats was in April and May, when the animals were seeking new green vegetation in bogs, riparian areas, and open meadows, and when they were migrating along river bottom corridors to their summer locations.

-The annual pattern of aggregation for the Spatsizi animals was essentially the same as that documented for other woodland caribou, with the smallest groups in late spring-early summer, increasing group sizes to at least a minor peak in fall, and then somewhat smaller groups in winter. The major departure from that pattern appears to be in severe winters, when animals may become concentrated in alpine areas far above the preferred forest winter range.

-As suggested by others, the reduced group size and high dispersion in June is probably at least partly an antipredator strategy to enhance calf survival.

-Summer grouping behavior after calving has included distinct though incomplete segregation of females with calves from other classes of caribou, lasting through the rut period for many individuals. That pattern may be a continuing expression of the above-mentioned antipredator strategy.

-During the four years of radio-tracking, almost all calving was completed between 25 May and 15 June, and the peak was probably in the period 3-8 June.

-Calving success among collared females varied from 68-75% for the two years with the largest sample, a rate that is below the 82% average suggested for the species. That relatively low calving success may reflect the generally old age of the female sample, since most non-parous females were the older ones.

-Calf survival observed among the collared animals appeared better than that documented in local fall composition counts in 3 of the 4 study years. It is apparent that the main cause of the difference was a negative bias in the fall counts, resulting from the failure of many females with calves to attend the usual survey areas during the rut.

-Although previous studies have documented high calf mortality in the Spatsizi area as a result of observations centered at Fire Flats, it is now apparent that the Fire Flats aggregation is not representative of the local population. It is composed mostly of males, non-parous females, and unsuccessful mothers, and few calves should be expected there.

-Predation on caribou calves may be an important factor bearing on population dynamics of Spatsizi caribou, but that has not yet been demonstrated, and particularly not to the exclusion of all other possible factors. Weather factors, especially during calving, cannot yet be ruled out. During this study, the poorest calf survival was during the year with the wettest early summer, and the proposed peak in the caribou population, in about 1970, followed a series of five of the driest early summers on record.

-Mortality of collared adults was variable from year to year, ranging from 3.7% of 27 animals in 1982-83, the year with the mildest winter, to 42.9% of 7 animals in 1981-82, the year with the severest winter. The adult mortality rate of collared animals over the 4 study years averaged 12.8% for females and as high as 14.9% overall, depending on whether one male actually died. The degree to which that represents the situation in the total population probably depends upon whether the relatively old age of the collared sample is representative, since it was mostly old animals that died.

-Predation was known or suspected to have been the cause of death for 2 of 10 adult mortalities, and was a possibility in 4 others, although other factors such as winter severity and/or old age doubtlessly also played at least a minor role by increasing vulnerability to other factors.

-There is some evidence for high mortality during the 1981-82 winter, but at least adequate recruitment and relatively low adult mortality indicate that the population has been increasing since that time. The failure of official fall counts to accurately document either population status or composition is briefly discussed.

-Above listed results on topics other than population dynamics were synthesized into a specific summary of the annual cycle of caribou in the Spatsizi area.

-Generally, it appears that western woodland caribou with access to alpine habitat have an annual cycle more like that of barren ground caribou than like that of eastern woodland caribou, which remain in low elevation forests throughout the year.

-The homing tendency of many individuals in spring, and subsequent local movements in summer and fall, may result in maintaining adjacent groups that remain largely separate. There appear to be at least three such groups, here termed "herds" in the Spatsizi-Tatlatui Parks area, including the "Spatsizi Herd" in the north, the "Upper Stikine Herd" in the southern and western portions of Spatsizi Park, and one or more as yet unnamed herds in the Lawyers Pass-Tatlatui Park area.

-Provisionally, the term "population" is suggested to apply to a group of herds sharing a common winter range. With that definition, management of the Spatsizi Population may be complicated by an annual distribution that overlaps several administrative boundaries.

-Management and research implications arising from the study include the following considerations:

a) Rut areas do not appear to be of the critical importance previously thought, because not all animals attend them, and because their use varies within and between years. Rather, the most important _habitat_ consideration appears to be protection of the universally used lower Stikine winter range, much of which does not now have park status.

b) Both political and biological views of _critical habitat_ require rethinking, since it is now evident that caribou need a large, diverse total range to maintain large and viable populations on a continued basis.

c) It has been demonstrated that short term, one time studies or _impact assessments_ may give, and have given in the Spatsizi area, distorted views of a population and its requirements, and may lead to wrong decisions _vis a vis_ habitat protection.

d) The widespread dispersion observed on _summer ranges_ apparently serves to preserve genetic and traditional variability among the Spatsizi caribou, particularly serving to preserve "movers" without which the population might become sedentary and fall permanently into reduced numbers.

e) Our observations of _population dynamics_ suggest that the Spatsizi caribou are not in the critical declining situation portrayed in other studies. Past recruitment assessments may have been pessimistic as a result of unrepresentative sampling, adult mortality is more varied than simple population models have predicted, wolf predation may be less serious than believed earlier, the population may be older than desirable, and weather factors may be significantly affecting mortality of both young and adults.

f) _Telemetry studies_ may include their own particular biases, depending especially on the age and sex representation of collared animals, and the overall representativeness of where and when they were captured.

-Recommendations for future management and research are given.

1. INTRODUCTION

1.1 OBJECTIVES

This is the second major progress report in a continuing radio-telemetry study of woodland caribou (*Rangifer tarandus caribou*; Banfield 1961) in the Spatsizi Wilderness Park area of northern British Columbia. The project was initiated in late fall 1980, as a preliminary step in a proposed, long term research program on large mammal predator - prey relationships in the area (Haber 1979, Hatler 1983). The need for such work was established by Bergerud (1978), who concluded that B.C. caribou were in a period of major decline, allegedly having been reduced by up to 50% during the 1970's. He believed that predation, including that by man in some areas, was the primary cause, and he and his co-workers have amplified that view in more recent publications (Bergerud 1983, Bergerud *et al.* 1984a).

The original study objectives, as listed in Hatler (1983) were to:

1) determine movements, seasonal habitat use, and annual range of the rutting herd selected, and
2) evaluate the assumptions and results of current inventory procedures.

Development and evaluation of inventory methods is the subject of a separate report (Hatler, in prep.). The focus here is on the first objective with additional information on herd cohesion, fidelity to specific ranges, aggregation behavior, and aspects of population dynamics.

The woodland caribou of the Spatsizi area are of the "ecotype" that feed, in winter, mostly on terrestrial vegetation rather than on arboreal lichens (Bergerud 1978, Stevenson and Hatler 1985). Unlike woodland caribou over most of the range of the subspecies, those in northern British Columbia, including the study area, have access to mountain uplands, and they regularly use them throughout the year. The Spatsizi animals are at the southern edge of a distribution that continues to the north to at least the southern Yukon Territory, and possibly into Alaska. A more detailed review of taxonomy and distribution is given in Hatler (1983).

Some of the previous publications producing data on Spatsizi caribou have been cited above. There have been others, including park and wildlife agency inventory work, local developmental impact studies, and incidental records from field studies on other resources. All such data sources are reviewed in light of present findings in Section 5.4.

1.2 STUDY AREA

In this study, the movements of the radio-collared caribou defined study area boundaries. Figure 1 shows the core area, including all of Spatsizi Park. During the four years of study, the animals regularly used areas up to 20 km north of the northern extent of Figure 1 and, in one case, a movement 90 km north of the map area was documented. Westward movements did not go beyond the area shown in Figure 1, but some animals regularly used areas up to 20 km beyond the southeastern corner. Local place names most regularly referred to in this report are shown in the frontispiece.

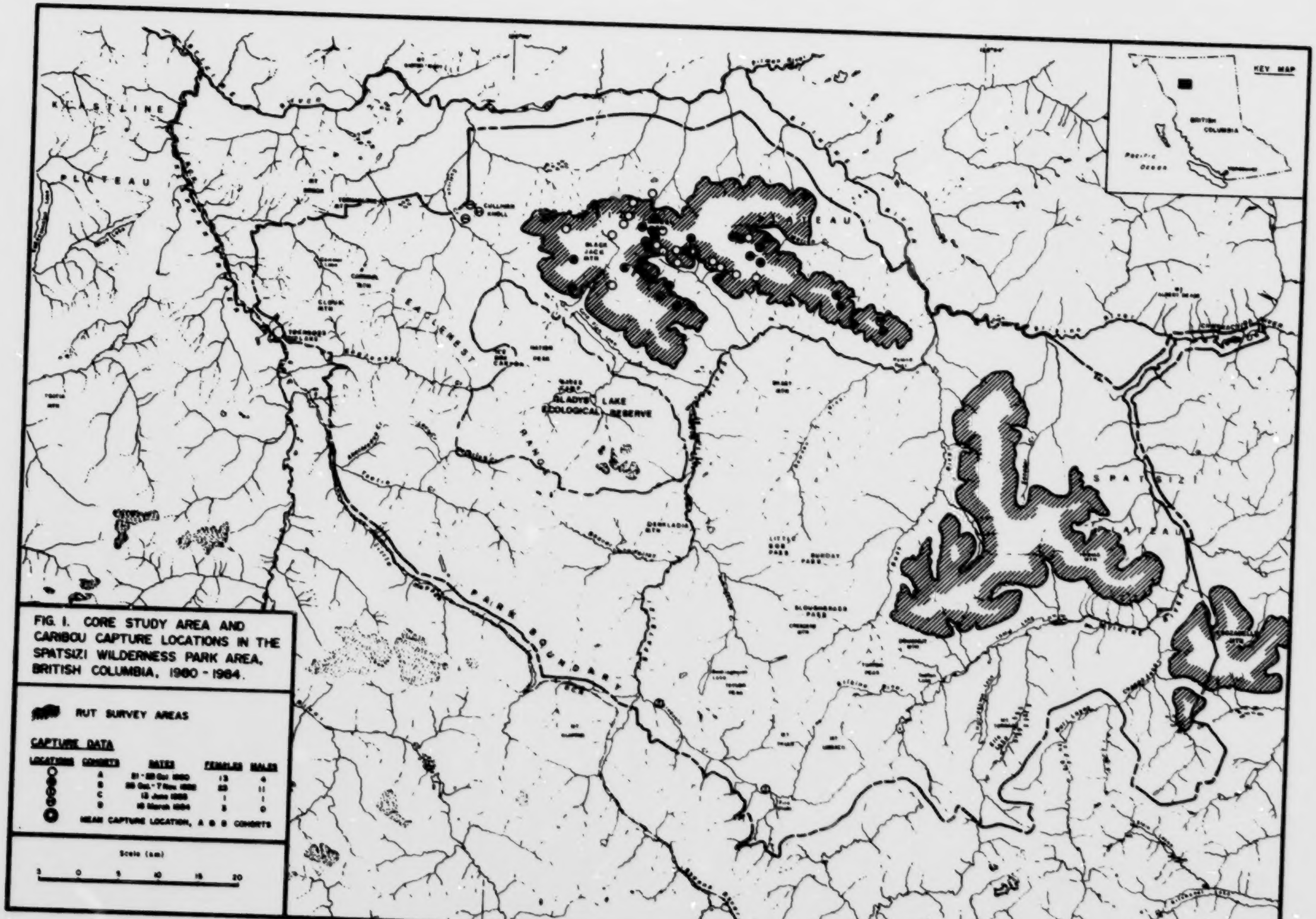
KEY MAP
BRITISH COLUMBIA
Pacific Ocean
KLASTLINE PLATEAU
EAGLENEST
RANGE
GLADYS LAKE ECOLOGICAL RESERVE
BLACK JACK MTN
CULLIVAN KNOLL
PLATEAU
SPATSIZI
PLATEAU
PARK BOUNDARY
LITTLE SIS PASS
SUNDAY PASS
RUT SURVEY AREAS
CAPTURE DATA
LOCATIONS
COHORTS
DATES
FEMALES
MALES
A
21 - 23 Oct 1980
13
4
B
26 Oct. - 7 Nov 1982
22
11
C
13 June 1983
1
1
D
16 March 1984
3
0
MEAN CAPTURE LOCATION, A & B COHORTS
Scale (km)
5
0
5
10
15
20

FIG. I. CORE STUDY AREA AND CARIBOU CAPTURE LOCATIONS IN THE SPATSIZI WILDERNESS PARK AREA, BRITISH COLUMBIA, 1980 - 1984.

The study area centers on the drainage of the Stikine River, particularly on the relatively flat, rolling uplands of the Spatsizi Plateau. The physiography, climate, soils and vegetation of that area and of the adjacent, more rugged Stikine Range of the southern Cassiar Mountains and the Eaglenest Range of the northern Skeena Mountains, were described in the previous report. Climatically, the area has "long, cold winters and short, cool summers with moderate precipitation which is well distributed throughout the year" (Schaefer 1978). Precipitation and normal snowpack increase both to the south, in the Skeena River drainage, and to the west in the drainages of the Klappan and Nass Rivers. The mountains in both of those areas are used by study area caribou in summer.

The plateaus and drier slopes and valleys of the Stikine system, used by caribou throughout the year but especially in fall and winter, lie mostly between about 1000 m and 1700 m, with few elevational prominences above 2100 m. Both the Stikine and Eaglenest Ranges, on the other hand, include numerous peaks of 2000 m or higher.

The Spatsizi area has "high vegetation diversity" (Pojar 1977). In a study area in the Eaglenest Range, he identified 35 community types in the three Biogeoclimatic Zones (Krajina 1965) represented there. Those included 8 forest, 7 shrub, and 6 herb community types in the Spruce-Willow-Birch Zone, which composes most of the area up to about 1700 m, and 2 shrub and 12 basically herb community types in the Alpine Tundra Zone. The Boreal White and Black Spruce Zone occurs primarily along the valleys of the major rivers in the area, manifesting itself as fairly continuous spruce-dominated forest. Owing to local variations in topography, soils and microclimate, and frequency of disturbance by fire and geomorphological processes, the 35 community types referred to above exist in a complex mosaic over the area, providing a great variety of habitats from which the animals can choose.

1.3 ACKNOWLEDGEMENTS

With organization and leadership by the Spatsizi Association for Biological Research, the Spatsizi project has been a cooperative venture. During the first years, funding or other direct assistance came from a variety of sources including B.C. Hydro and Power Authority, B.C. Ministry of Environment (Wildlife Branch), B.C. Ministry of Lands, Parks and Housing (Parks Branch), the MacLean Foundation, the Stikine Foundation for Wilderness Studies, the Koerner Foundation, the Vancouver Foundation, Dr. A.T. Bergerud (University of Victoria), the Guide-Outfitters Association of British Columbia, and anonymous private donations channeled through the World Wildlife Fund. Recently, most funding has come from Parks Branch, Wildlife Branch, the Canadian National Sportsman's Fund, and generous grants from Gulf Canada Ltd.

Former Executive Director Lamont Bassett generated and organized most of the funding; Dr. D. Pitt-Brooke, D.V.M., and R. Page, biologist, provided important expertise and field assistance during the main capture expeditions; Ray and Reg Collingwood have been generous and cooperative in providing facilities and information; Tom Britton and Tom Brooks have served as unusually competent pilots and as field assistants,

logistical organizers, equipment maintenance personnel and good company; Don Eastman (Wildlife Branch) and Greg Jones (Parks Branch) were the project's Cavalry, one or both always riding in to save the day whenever needed, and both providing much appreciated advice, support and encouragement; Herb Green was understanding and supportive in his role as a Parks Branch administrator, and he even chopped kindling, hauled water, and held caribou legs and antlers when required; other provincial government staff to cite include Ian Hatter, who worked "beyond the call" to assist with computer analyses, Laura Friis, who handled the technical aspects of determining caribou ages, and Bruce MacLean and Bob Marsh , both of whom were prompt, thorough and helpful in dealing with requests for weather information; Leslie Boot rode white-knuckled in aircraft, cooked for hungry capture and survey crews, and typed various versions of this report; Evi Coulson transformed my cluttered concepts into the various figures which appear in these pages; special thanks are due to reviewers J. Kelsall, D. Eastman, D. Russell, A.T. Bergerud, and A. Harestad for the suggestions and stimulation which, I believe, have made this report much better than it might have been.

Overall, the project owes its development and continuation to the Spatsizi Association for Biological Research, whose aim is to foster research and management of big game in northern British Columbia. The members of that group are listed on the following page:

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Fred Bunnell, Langley, B.C.

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J. Bristol Foster, Ganges, B.C.

*Irving Fox, Smithers, B.C.

Greg Jones, Victoria, B.C.

Robert D. Harris, Vancouver, B.C.

Robert Henderson, Telkwa, B.C.

John P. Kelsall, Delta, B.C.

*Vladimir Krajina, Vancouver, B.C.

Barry Leach, White Rock, B.C. (resigned)

James Pojar, Smithers, B.C.

*Richard Stace-Smith, Vancouver, B.C.

*T.A. (Tommy) Walker, Smithers, B.C. (resigned)

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* Founding members

2. METHODS

2.1 STUDY TIMING

The results of the initial capture expedition in October 1980 and 22 radio-tracking flights during the first calendar year, i.e., through October 1981, were given in Hatler (1983). The present report adds findings for census and capture activities and 37 more flights between November 1981 and November 1984 (Fig. 2). Tracking flights were most regular, averaging almost two per month, during the first year. In subsequent years, after we knew better what to expect, the overall tracking schedule was reduced to about one per month, but with generally greater coverage in winter, when identification of habitats used is important, and during the May - June period, when females disperse to have their calves. The gap in records for the late summer - early fall period is partly by design, since previous observations indicated that the animals were relatively sedentary at that time. However, contingencies also played a role, with bad weather, budgetary constraints and, in 1983, loss of our pilot all being contributing factors.

2.2 CAPTURE AND HANDLING

Capture procedures for the initial cohort of collared caribou were detailed in Hatler (1983). All animals were gently herded, by helicopter, to where they could be darted by concealed gunners on the ground. Caribou were immobilized with a "cocktail" of etorphine hydrochloride (M99) and xylazine (Rompun). Once in hand, animals were measured, radio collars and/or other marking devices were attached, and any wounds, including that due to the dart, were attended to by a veterinarian. The ages of animals

Figure 2. Chronology of caribou radio-tracking flights in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984.

	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	Number of Flights
1980-81	1 2	3 4	5 6 7	8 9	10 11	12	13 14 15	15 17 18	19	20		21 22	22
1981-82		23		24 25	26 27		28	29 30		31	32	33	11
1982-83	34	35	36 37	38 39	40	41	42 43	44 45	46			47	14
1983-84	48		49	50	52 52		53 54	55 56	57			58	11
1984-84	59												1

FLIGHT DAYS

1. 22 Nov
2. 28 Nov
3. 6 Dec
4. 22 Dec
5. 2 Jan
6. 15 Jan
7. 29 Jan
8. 16 Feb
9. 28 Feb
10. 17 Mar
11. 29 Mar
12. 16 Apr
13. 3 May
14. 20 May
15. 30 May
16. 9 Jun
17. 18 Jun
18. 26 Jun
19. 24 Jul
20. 30 Aug
21. 8 Oct
22. 12 Oct
23. 16 Dec
24. 6 Feb
25. 24 Feb
26. 3 Mar
27. 16 Mar
28. 10 May
29. 7 Jun
30. 30 Jun
31. 31 Aug
32. 27 Sep
33. 25 Oct-7 Nov
34. 4 Nov
35. 2 Dec
36. 6-8 Jan
37. 31 Jan-2 Feb
38. 13-14 Feb
39. 28 Feb
40. 22 Mar
41. 12-13 Apr
42. 10-11 May
43. 31 May-1 Jun
44. 12-14 Jun
45. 29 Jun
46. 28-29 Jul
47. 9-10 Oct
48. 22 Nov
59. 8 Jan
50. 21-22 Feb
51. 13-14 Mar
52. 15-20 Mar
53. 7-8 May
54. 10 May
55. 4-5 Jun
56. 12-16 Jun
57. 20-21 Jul
58. 5-8 Oct.
59. 26-27 Nov

captured were estimated in the field, based on degree of tooth wear, body size and antler characteristics. Whenever possible, an incisor was also extracted and actual age was later determined by counts of cementum annuli. In all, 18 animals were captured during the period 21-28 October 1980, and 17 were released alive, 15 with radio collars.

Using those same procedures, 36 more caribou were captured between 24 October and 7 November 1982, and 35 were released with radio collars. Capture success was somewhat poorer in 1982 than in 1980, apparently because of problems with drug quality and/or temperature effects. Subsequent to 1982, eight more caribou were handled and collared in three separate sessions. All were taken with a hand-held CODA net gun (Telonics Telemetry-Electronics Consultants, Mesa, Arizona), discharged from a helicopter. Caribou taken with the net gun were not drugged, therefore they could not be measured and teeth were not extracted. The animals were simply collared, disentangled from the net, and released. Appendix 1 provides additional information on capture activities and successes between 1982 and 1984.

The two main collaring projects were timed to take advantage of concentration by the animals in open upland habitats in the fall, but late enough to avoid interfering with rut activities. Also, since most northern "herds" are named by their rutting area, the rut location was considered the major reference point in an animal's annual cycle. The net captures were timed primarily to take advantage of the presence of a helicopter, chartered for other purposes.

2.3 AERIAL RADIO-TRACKING

All electronic equipment was procured from Telonics (Mesa, Arizona). The first 15 collar-transmitter packages, used in 1980, were the "Configuration 5B" model, with TA-5-HT antennas and without mortality/motion sensors. All collars applied after 1980 were the larger "Configuration 6B" type, with TA-5-HT/dipole antennas, and with normal mode motion sensors designed to increase pulse frequency after a collar has been motionless for 6 hours. All transmitters were in the 148-149 MHz frequency range. Transmitter performance to date has been very good (details available from the author).

The receiving system included a TS-1/TR-2 programmable, scanning receiver and a pair of RA-2AK, two-element Yagi antennas, one on each wing strut of the fixed-wing survey aircraft, and both mounted to be "forward looking". Antenna leads were joined in a TAC-2, RLB control unit, which enabled the user to switch back and forth between left and right, or to use both antennas simultaneously. A major refinement in our radio-tracking since the first report (Hatler 1983), was the use of a TADS-2-ISOP intercom system, which enabled the pilot and researcher to communicate comfortably while both were listening for signals. More importantly, it made locating the animals more efficient by enabling the pilot to respond to the signal directly rather than to hand or vocal signals from the receiver operator. In our tracking flights, the pilot routinely operated the right-left switch box while flying, making it easier for the passenger to attend to receiver operation, mapping and data-taking.

Occasionally a Bell 206 helicopter was used to ensure observation of collared animals or to locate collars on mortality mode. In such cases, a single antenna was attached to the main helicopter communication mast ("stinger"), mounted looking forward and slightly downward. That arrangement was sufficient for close-range tracking, when a transmitter's rough location was known, but was inefficient for extensive searching.

All of the fixed-wing tracking was conducted in Cessna 180 and 185 aircraft. All but four of the tracking flights since early 1981 were in the same 185, owned by Central Mountain Air Services Ltd., Smithers, B.C. That aircraft was specially maintained to eliminate interference and static from the magnetos and alternator. Procedures for locating the collared animals were described in Hatler (1983), and need not be repeated here except to emphasize that in the rugged mountains of the study area, it was essential to get high elevation for efficient searching. We regularly searched from 3500-4200 m, and therefore attempted to limit tracking activities to days with broken or no cloud cover.

Once a signal was received, the animal was "tracked" until seen, or until we were satisfied that additional passes were not likely to yield a sighting, e.g., in thick timber. In some cases, caribou were seen at a signal location without the collar itself being seen. That was particularly true for large groups, or when flying conditions were too hazardous for a close approach. In such cases, we assumed that the collared one was in the group seen. In winter, fresh tracks often confirmed the presence of animals at the location of greatest signal strength.

At other times, when neither animals nor tracks were visible, locations were determined by signal strength and local cover characteristics. For example, if a signal came from near timberline, and no animals or sign could be seen in upslope, open areas, it was assumed that the animal was in the timber. Occasionally, usually because of locally deteriorating weather, we had to terminate a particular search without obtaining a satisfactory location point. In such a case we simply recorded the fact of contact in a general location.

All satisfactory contact locations were mapped, in flight, on 1:250,000 scale maps (National Topographic Series). Associated data for each contact, recorded on a small, hand-held tape recorder in flight, included a broad habitat designation (alpine, subalpine shrub, coniferous or deciduous forest, or other), estimated elevation to the nearest 25 m, aspect (eight compass points), and group size. Although flying conditions occasionally allowed determination of group composition, that was usually not possible from the fixed-wing aircraft except for small groups.

2.4 CALVING STUDIES

It was important to determine maternal status, which appears to affect movements and habitat selection of females throughout the summer and fall. An attempt was made to locate and closely observe all females during tracking flights in early June, when most calving occurred, and in mid-June, by which time it was essentially complete. For females seen with calves on either of those flights, the status was considered confirmed. In 1983 and 1984, immediately following the mid-June fixed-wing flight, a

Bell 206 helicopter was used to locate all females not seen from the fixed-wing, and those seen without calves. In addition to the usual habitat and group size data recorded for all observations, females without calves were described in terms of udder size and antler characteristics, to provide evidence as to whether they had given birth and subsequently lost calves, or might still be pregnant (see Bergerud 1964, 1976).

2.5 RUT SURVEYS

Following the example and advice of Bergerud (1978; pers. comm.), management agencies in British Columbia currently seek comparable data on northern caribou herds by composition counts of fall concentrations of the animals on traditional upland rutting areas. There are three such areas in Spatsizi Wilderness Park (see Fig. 1):

1) Caribou Mountain - Marion, the initial capture location for all but two of the radio-collared caribou in this study.
2) Tomias Mountain area
3) Edozadelly Mountain

Fall counts have been obtained in one or more of those areas annually since 1976. Since the first animals were collared, survey coverage, flight dates and personnel were as follows:

1981 - Caribou Mountain and Edozadelly, 9-11 October: Parks Branch and Spatsizi Association for Biological Research.

1982 - All three areas, 4-6 October: Parks Branch, Wildlife Branch, A.T. Bergerud.

1983 - Caribou Mountain and Edozadelly, 9 October: Parks Branch, Spatsizi Association for Biological Research.

1984 - All three areas, 6-9 October: Parks Branch, Wildlife Branch, Spatsizi Association for Biological Research.

The rut surveys did not involve systematic sampling; rather, they were attempted total counts of all caribou on the upland rutting areas. A Bell 206 helicopter was used to search the designated areas intensively, by flight patterns and elevations judged in flight to be most likely to locate all animals present. Once located, groups were counted and individual animals classified as large, medium or small bulls, adult females, calves, and unclassified adults. A complete description of census procedures, including animal classification criteria, is given in Hatler (1983).

2.6 WEATHER DATA

Weather conditions were routinely noted during all field studies. In winter, snow depths were monitored during each trip on the airstrip at Hyland Post, the main field camp. Long-term weather patterns were determined by reference to records for Dease Lake, the only permanent weather station in the general area, and from data collected at several smaller temporary stations in the Stikine watershed. Those stations, established and maintained by B.C. Hydro and Power Authority in relation to hydrological studies, provided a good measure of the local range of conditions to which the caribou were exposed (Hatler 1983).

2.7 DATA ANALYSIS

For this report, data from Hatler (1983) and all subsequent radio-location information were coded, stored and analyzed in a computer system. Home ranges were calculated in a program by Harestad (1981), as modified by R. Roberge and R. Page, B.C. Ministry of Forests. Movements between specified animal locations were calculated by computer analysis of grid coordinates describing those locations. Because this is a progress report on a continuing study, the primary emphasis is on presentation rather than intensive analysis of results. Most numerical data are accompanied by descriptive statistics, providing an indication of variability (SD) and sample size. However, since differences between individuals seem to be more important than similarities, as measured by means, most data are also cast into frequency classes. A few statistical tests (chi-square from 2 x 2 contingency tables, Siegel 1956) are presented for conclusions that reviewers considered contentious.

3. RESULTS

3.1 WEATHER

The nearest permanent weather station to the study area is at Dease Lake, approximately 140 km northwest of Hyland Post. At 795 m, it is lower than all valley bottoms in the study area except that of the Stikine River near the mouth of Cullivan Creek. Therefore, Dease Lake temperatures probably average somewhat milder, especially in summer, and winter snowpack may be less than in most of the areas occupied by the caribou of this study. The extent and nature of precipitation in the area no doubt vary locally, but broad patterns in the Dease Lake area may also apply to the Spatsizi area, especially in regard to comparisons among years.

Table 1 lists features of Dease Lake weather for the four years of this study in comparison to the 25-year normals for that station. The winter of 1981-82 was the only one during the study years that maintained colder than normal temperatures. December through March temperatures were somewhat colder than normal in early winter during 1982-83 and 1983-84, but warmed to above normal averages after December. The warmest study year was the first one, 1980-81, with most winter temperatures above normal and with June through September temperatures well above normal.

The study years were generally wetter than normal. Total precipitation in 1983-84 was below normal, but it nevertheless fell on a greater than normal number of days with measurable precipitation in that year. The year of highest total

Table 1. 1980-84 weather in comparison to the 25 year normals at Dease Lake, British Columbia. Data listed, rounded to nearest whole numbers, are from Environment Canada (Atmospheric Environment Service) series "Canadian Normals", and from files of the Air Services Branch, B.C. Ministry of Environment, Victoria.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
Mean Daily Temp. (°C)													
Normal	1	-8	-15	-19	-13	-7	0	6	11	13	11	7	-1.2
1980-81	3	-4	-22	-8	-10	-2	-2	8	15	20	20	13	2.7
1981-82	2	-6	-18	-28	-16	-7	-2	5	13	14	11	8	-2.0
1982-83	1	-12	-16	-15	-13	-7	2	7	11	12	10	6	-1.2
1983-84	1	-10	-23	-12	-7	-2	2	6	10	12	11	6	-0.5
Mean Total Ppt. (mm)													
Normal	34	32	30	28	26	21	12	21	38	54	54	44	394
1980-81	30	13	90	8	26	17	35	60	68	34	53	40	472
1981-82	39	35	20	99	19	38	11	24	3	54	86	23	451
1982-83	26	20	12	24	24	3	17	41	76	91	57	52	443
1983-84	17	9	10	51	44	27	7	15	51	20	60	40	351
Mean Snowfall (cm)													
Normal	19	34	33	30	29	23	12	5	1	1	<1	1	187
1980-81	10	13	109	11	36	17	37	0	<1	0	0	<1	233
1981-82	4	28	31	142	25	68	19	3	0	0	0	0	320
1982-82	19	24	15	32	31	4	17	1	0	0	0	3	146
1983-84	6	15	17	61	14	13	8	2	<1	<1	1	2	139

precipitation was 1980-81, owing to a three times normal snowfall in December and much heavier than normal precipitation in the April-June period. During the remaining eight months, precipitation in that year was at or below normal, and the summer period, July through September, was the driest during the study.

Snowfall was somewhat above normal in 1980-81, due to the heavy December total mentioned above, and was almost twice normal in 1981-82. The January 1982 total of 142 cm was almost five times normal for the month and that was followed by a March snowfall that was three times normal. The last two years were below normal in snowfall, with little coming after February in 1982-83 and only a small amount after January in 1983-84.

Observations in northern B.C. caribou habitat during several summers indicate that there may be considerable annual variation in weather conditions at that time. Appendix 2 lists detailed annual precipitation data since 1951 for five time periods in June, and for July and August. Figure 3 depicts patterns during the calving (1-10 June) and immediately post-calving (11-20 June) periods, based on 5-year means and compared to a 34 year average. The trend has been to increasingly wetter summers, especially in the last decade. The late 1960's were consistently the driest years on record, particularly during June and July. Over the years, July has averaged slightly wetter than August, and both have averaged 10 mm more precipitation than June.

Figure 4 shows snow depths measured by B.C. Hydro during the study years at two upland stations, and at five lowland stations near known caribou wintering areas. The snow accumulation patterns on the lowland sites approximated those measured at

Figure 3. Summer precipitation patterns at Dease Lake, British Columbia, 1951-1984.

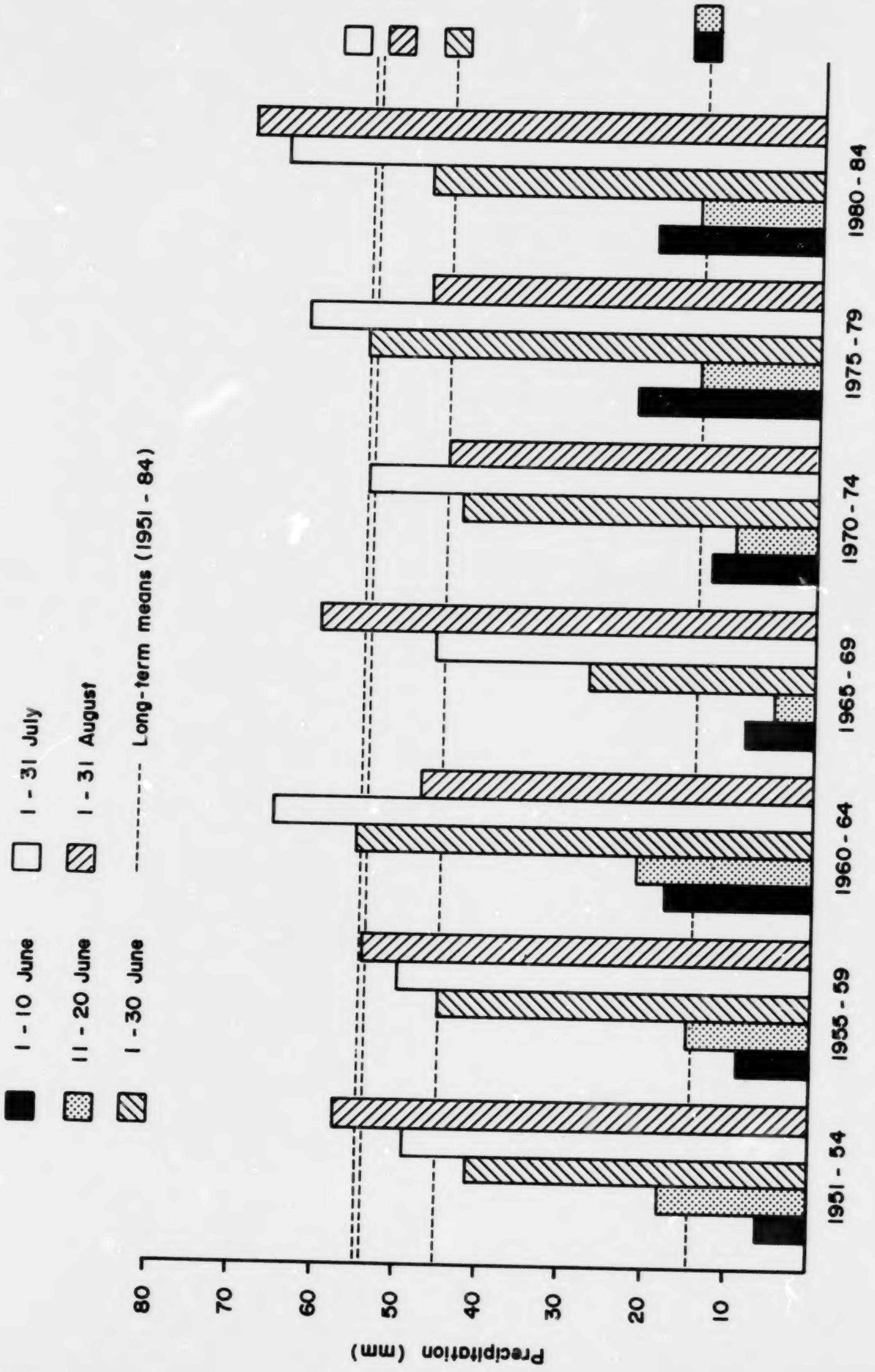
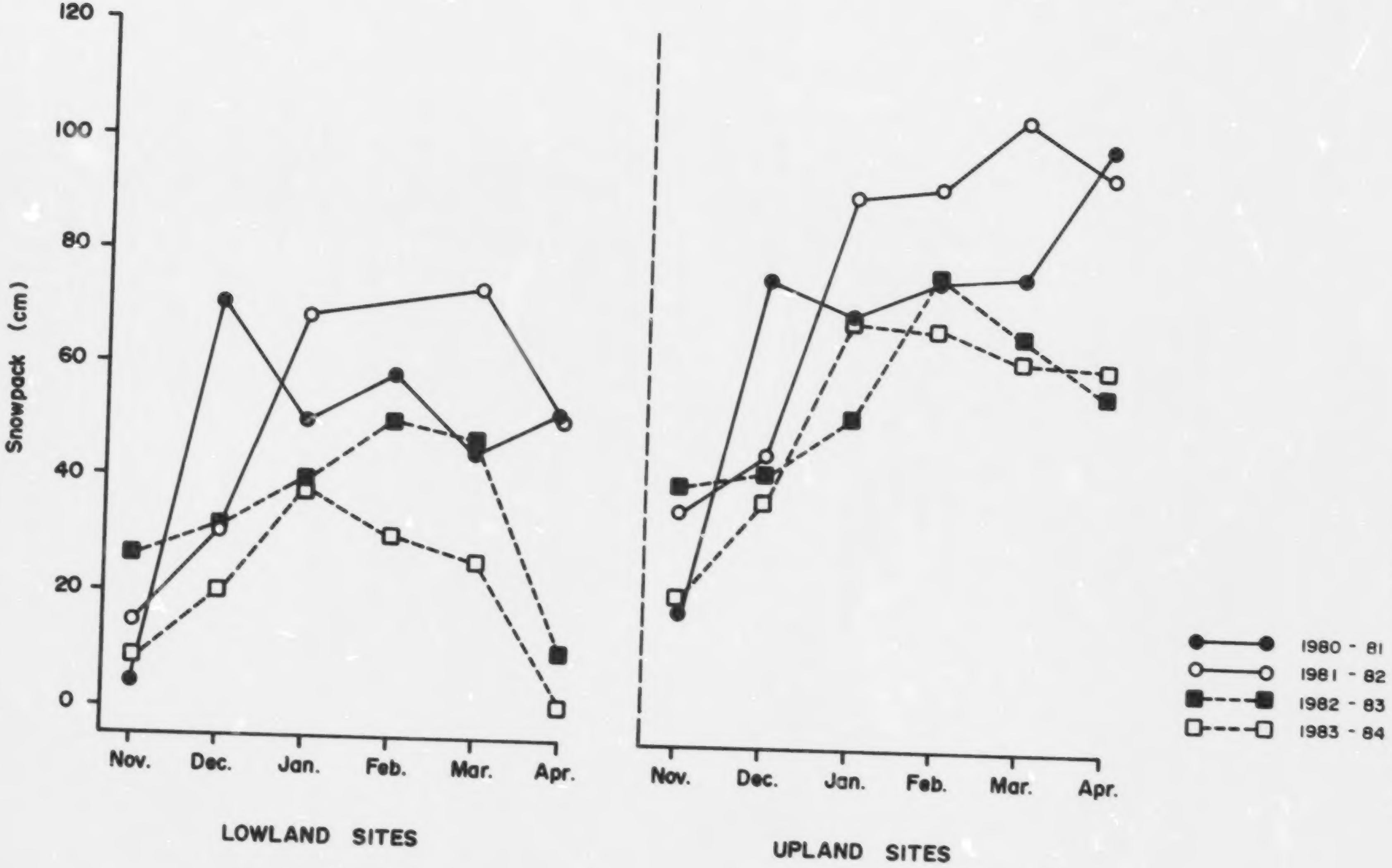

1 - 10 June
11 - 20 June
1 - 30 June
1 - 31 July
1 - 31 August
Long-term means (1951 - 84)
Precipitation (mm)
80
70
60
50
40
30
20
10
1951 - 54
1955 - 59
1960 - 64
1965 - 69
1970 - 74
1975 - 79
1980 - 84

Figure 4. Monthly snowdepths at B.C. Hydro weather stations in the Spatsizi Wilderness Park area, British Columbia, 1980-1984. The values for upland stations are means for Eaglenest Creek and McBride 5000 (mean elevation = 1512 m), while those for lowland stations are means for McBride River, Klappan, Pitman, Dawson and Chukachida (mean elevation = 945 m).


Snowpack (cm)
120
100
80
60
40
20
0
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
LOWLAND SITES
UPLAND SITES
1980 - 81
1981 - 82
1982 - 83
1983 - 84

Dease Lake in 1980-81 (Hatler 1983). The B.C. Hydro data within the study area confirm conclusions about the four winters as determined from Dease Lake data, i.e., the heaviest snow accumulation was in 1981-82, and in the last two winters, especially 1983-84, there was relatively little snow.

3.2 PHYSICAL CHARACTERISTICS OF SPATSIZI AREA CARIBOU

Appendix 3 lists known or estimated ages and selected measurements for 25 female and 11 male caribou handled during the October-November 1982 capture program. Table 2 compares mean body measurements for the combined sample from 1980 and 1982 to those for woodland caribou in northeastern Alberta.

3.2.1 Age

Difficulties in counting cementum annuli resulted in some tooth ages being listed initially as a range, e.g., 8-9. In such a case, the age given in Appendix 3 is 8+, meaning "at least 8" and the lower number, 8 in this case, was used in statistical calculations. Thus, the mean ages recorded in this study are conservative. A comparison of estimated ages and tooth ages for the 25 animals from which teeth were obtained indicated that underestimates were the rule. Only one animal was estimated to have been older than it actually turned out to be, a 2 year old female estimated to have been three. However, all animals judged to have been 3 years old or less in the field were 1 to 3 years by tooth age, and all judged older than three were indeed older. Therefore, the 11 animals for which no tooth ages were obtained can be assigned with some confidence to two age categories, young adult (1-3 years) and adult (4+ years).

Table 2. Body size among caribou captured in Spatsizi Wilderness Park, British Columbia, 1980 and 1982, as compared to that in northeastern Alberta (Fuller and Keith 1980). The age separation indicated is between young adults (YA), known or estimated 1-3 years old, and older adults (AA), at least 4 years old.

Sex		Selected Measurements (cm)											
		Total Length				Shoulder Height				Heart Girth[1]			
Location	Age	N	Range	Mean	SD	N	Range	Mean	SD	N	Range	Mean	SD
Females													
Spatsizi	YA	10	180-211	196	10	10	105-128	117	7	11	121-138	131	6
	AA	21	190-219	203	8	21	103-137	120	8	22	123-144	133	6
	ALL	31	180-219	201	9	31	103-137	119	8	33	121-144	132	6
Alberta	YA	3	-	198	17	-	-	-	-	3	-	137	6
	AA	7	-	196	4	-	-	-	-	7	-	141	11
Males													
Spatsizi	YA	7	202-236	215	11	6	113-135	126	8	6	127-142	137	6
	AA	8	206-230	222	8	8	130-158	141	8	8	138-152	145	4
	ALL	15	202-236	219	9	14	113-158	135	11	14	127-152	141	6
Alberta	YA	6	-	197	5	-	-	-	-	6	-	141	9
	AA	17	-	219	10	-	-	-	-	17	-	154	6

---

[1] Heart Girth: girth just behind front legs; the girth listed for the Alberta sample was termed "chest girth" by Fuller and Keith (1980), and may not be the same.

The female sample included one yearling, three animals known and four estimated to be 2-5 years old, twelve with tooth ages >5, and four with estimated ages of 4+. Of the older tooth-aged females, nine were 10 years old or more, to a maximum of 16 years. The mean for 16 female tooth ages was 8.5 years (SD 4.6).

For the males, the single estimated age was for an animal believed to be 3 years old, i.e., a "young adult". Other ages ranged from 2-9 years (Mean 4.7, SD 2.6). Field age estimates were generally closer to tooth ages for males than for females. The greatest departure was for the oldest animal, actually 9 years old but estimated to have been only 4. His antlers, though having the longest beams measured, were regressing to subadult characteristics, having no palmate shovel, relatively few points overall, and generally light main beams.

3.2.2 Body Size

The Spatsizi caribou were similar in size to those of comparable age in Alberta (Table 2). Some females among those captured in both 1980 and 1982 were noticeably larger than others, approaching or even exceeding body measurements and antler size for 2 to 3 year old males.

3.2.3 Antler Size

As expected, Spatsizi bulls 2-3 years old had smaller antlers and fewer points than those 4 years and older (Table 3). The longest beams were on the oldest bull (9 years), but he had relatively few points (9 and 10) and the brow tine (shovel) was not palmate. Signs of antler regression were also evident in No. A15, a 10-year-old bull captured in 1980 (Hatler 1983) and in B28, an animal with a minimum tooth age of eight. The only known

Table 3. Antler characteristics among caribou captured in Spatsizi Wilderness Park. The data, rounded to the nearest whole number, are a composite from cohorts in 1980 Hatler (1983) and 1982 (Appendix 3, this report). N refers to the number of single, intact antlers represented, i.e., usually two per animal. Young adults are those known or estimated to be 1-3 years old; older adults, known or estimated to be at least 4 years old, include the specific age categories (minimum ages as determined by cementum annuli counts) farther down the list.

Sex		Antler Length (cm)				Number of Points			
	Age Class	N	Range	Mean	SD	N	Range	Mean	SD
Males									
	Young Adults	11	24-79	60	16	11	3-11	6.4	2.5
	Older Adults	14	80-104	93	9	14	8-16	11.4	2.4
	5 Year Olds	6	80-101	88	8	6	11-16	13.2	2.1
	8-10 Year Olds	6	91-104	97	5	6	8-11	9.8	1.2
Females[1]									
	Young Adults	20	3-47	32	11	22	1-5	3.0	1.3
	Older Adults	38	10-51	38	10	40	1-7	4.1	1.5
	5-9 Year Olds	8	42-51	45	3	8	4-6	4.9	0.8
	10-12 Year Olds	8	28-48	40	7	10	3-7	4.4	1.4
	13-16 Year Olds	4	23-36	30	6	4	1-3	2.3	1.0

[1] Figures not including an unusually large female (No. B22, main beams both 66 cm long, with 11 points on one and 9 on the other), and two females which had no antlers (No's A08 and B19).

4-year-old, B30, had developed a somewhat palmate shovel, with four points, and had main beams both measuring 96 cm. However, there were only seven and nine points, respectively, on the beams behind the brow. Three 5-year-olds in the sample, one from 1980 and two from 1982, all had representative, mature antler complements with palmate shovels and four or more antler points on each side. Those three animals had the largest average in number of points, although their antlers averaged somewhat smaller than those of three older bulls.

There were no 6-year-old bulls among those captured, but when No. A16 was that age, in fall 1981, he had an enormous set of antlers, judged to be "high record book" size by the local guide-outfitter*. No. B35 had fairly large antlers at age 3-4 in 1983, and had attained a large, mature antler complement by fall 1984, at age 4-5. The single 7-year-old among the captured animals, No. B33, had already shed his antlers when he was captured on 5 November 1982. From the foregoing, it appears that Spatsizi area bulls have subadult antler characteristics through age 3, attain the fully mature development by 5, reach a peak at 6 or 7, and regress thereafter.

Females showed a less clear separation in antler development between the 2 to 3 year olds and those 4 or older. Nevertheless, there was a trend to both increased antler length and number of points with age (Table 3). Antler development in females appears to peak between 5 and 9 years, although 10 to 12 year olds had antlers only slightly smaller. Two of the very large females, Nos. B18 and B22, had the largest antlers and were 9 and 12 years old, respectively. Both females older than 12 had antlers smaller than average, indicating antler regression at that time. The antlers on the oldest, B12 at 16 years, measured only 23 cm (2 points) and 26 cm (1 point).

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*Reg Collingwood encountered A16 at least three times during the hunting season of 1981, and twice talked hunters out of shooting him; A16 died in winter 1981-82.

3.3 RADIO-TRACKING SUCCESS

A total of 54 Spatsizi caribou were fitted with radio collars during the study period, although the number of active collars at any one time varied from 4 in September 1980 to 40 just after the 1982 capture expedition. At the end of the study period, the collared sample consisted of 26 animals. The rate of loss varied between the sexes, with 12 of 16 males (75%) dying or losing their collars, as compared to 16 of 38 (42%) for females. Slightly more than half of all losses occurred between capture and the first tracking flight, less than one month later. Those losses included some mortality, most apparently capture induced (see Appendix 1), although the major cause of loss among males was poor collar retention. Most of the males were captured just after the rut period, when their necks were still swollen to near maximum size, and the collars apparently could not be attached tightly enough under those circumstances. Of the four "surviving" males, three were collared in the October-November period as subadults, i.e., animals without significantly swollen necks, and the fourth was a young male captured in June.

Of 13 losses recorded after the first tracking flight, 10 are known to have been mortalities. Those losses are discussed in the section on population dynamics. The other three losses included a failed transmitter on a female observed alive as recently as October 1984, and either a failed transmitter or a long-distance movement by a young male (A14) that was successfully located on 23 of 24 tracking flights, through February 1982, and then was not heard from or seen again. The third loss was a young male (B34) that either died or shed his collar in a thick timbered area far from the nearest potential landing site. He had been successfully located on seven previous tracking flights, through April 1983.

Appendix 4 lists the individual tracking histories for all 39 caribou that survived to be located five or more times each. Four animals, all females, were tracked over the entire 49-month period for this report, yielding from 44-52 radio-locations each. Of the animals captured in fall 1982, 17 survived the full 24 months to the end of the study period and were located on 15-21 of the 21 complete tracking flights during those two years and 17-27 times overall. The two animals captured in June 1983 and the three collared in March 1984 were located 5-11 times each, in subsequent tracking flights.

The 39 collared animals observed for all or part of the November 1980 through 1984 study period collectively contributed 851 animal months of telemetry signal transmission (Table 4). A total of 840 satisfactory locations were obtained during that time, averaging approximately one location per animal month. That total constitutes the primary data base for following findings on animal movements, ranges, and other aspects of their biology. The emphasis here is on females, which were represented

Table 4. Collar retention, collared animal survival, and tracking history among 54 woodland caribou captured and instrumented in Spatsizi Wilderness Park, British Columbia, 1980-1984. Causes of losses included confirmed mortality (Mort.), loss of collar or transmitter failure (Col.) or unknown (Unk.), i.e., mortality, collar loss, transmitter failure or extensive movement from study area all possible. The sum of all losses is indicated by T.

Cohort, by Capture Date		Losses of Collars										
		Before First Flight				After First Flight						
Sex	Number Collared	Mort.	Col.	Unk.	T	Mort.	Col.	Unk.	T	Number Survived To Nov. 1984	Animal Months[1]	Total No. Locations
Oct 1980												
Male	4	-	1	-	1	2	-	1	3	0	39	56
Female	11	2	-	1	3	3	1	-	4	4	253	278
Both	15	2	1	1	4	5	1	1	7	4	292	334
Oct - Nov 1982												
Male	11	2	4	1	7	0	-	1	1	3	80	71
Female	23	4	-	-	4	5	-	-	5	14	421	399
Both	34	6	4	1	11	5	-	1	6	17	501	470
June 1983												
Male	1	-	-	-	-	-	-	-	-	1	17	5
Female	1	-	-	-	-	-	-	-	-	1	17	11
Both	2	-	-	-	-	-	-	-	-	2	34	16
March 1983												
Female	3	-	-	-	-	-	-	-	-	3	24	20
All Cohorts												
Male	16	2	5	1	8	2	-	2	4	4	136	132
Female	38	6	-	1	7	8	1	-	9	22	715	708
Totals	54	8	5	2	15	10	1	2	13	26	851	840

---

[1] Number of months times number of active collars per month over the study period.

in 84% of both animal months and satisfactory locations recorded (Table 4).

Appendix 5 catalogues individual tracking success on all complete tracking flights during the study period. In general, the proportion of animals found in relation to those known present was highest in January through April, when the animals were most sedentary. Poor tracking success was recorded in late May and early June of both 1981 and 1983, when the calving locations of many new collared females had not yet been discovered. Also, relatively poorer tracking success was recorded during the rut in most years, apparently as a result of high animal mobility and relatively low predictability at that time. Overall, satisfactory locations were obtained for 87% of all possible contacts over the 4-year period. Sightability was generally low, especially in winter at which time on a few occasions 20 or more animals were located without any being seen. One or more animals were actually seen at the signal location on only 335 (46%) of 736 otherwise successful contacts during the study period.

3.4 HOME RANGE SIZES

3.4.1 General

The term "home range" is defined as the minimum area occupied by an individual animal over a specific period of time, calculated on the basis of all radio-locations for that animal during that time period. The term should not be interpreted as connoting any particular regularity or predictability of either location or area of use. Calculated areas of home range were extremely variable, with total area ranging from about 1000 km^2

to 4000 km² among the four females with 40 or more locations over the 4-year period, and from about 500 km² to over 11,000 km² among females tracked for only two years. The 11,000 km² range for B18 was considered exceptional and has been deleted from statistical descriptions of the home range data in Table 5.

Appendix 6 lists individual home range data for all animals contacted 5 or more times. Some of the factors that might have contributed to the observed variability in those data are examined and other aspects of the home range results are presented in following sections.

3.4.2 Sexual Differences in Home Range Size

Males generally had smaller observed home ranges than did females, with a spread of 1455 km² to 3102 km² for the three with the longest tracking history (2 years, see Appendix 6). The single male in the 15-19 locations category occupied an area larger than the home ranges of four and smaller than that of one female in that category (Table 5). However, 10 of 12 females had ranges larger than all 4 of the males in the 20-24 locations category. Considering cumulative totals for animals with home ranges based on 15 or more locations, the mean for females was 53% higher than that for males (F: X=2554, SD 1445, N=25, female B18 excluded; M: X=1668, SD 926, N=5).

The above conclusions are based strictly on known locations. The incidence of failure to find males on tracking flights was about 4% higher than that for females (Appendix 4). Animals may have been missed because they were well outside the area searched, in which case some ranges, including those for both sexes, might have been larger than observed. The loss of male

A14 was ascribed to either transmitter failure or long-distance movement from the study area.

Because of the relatively small sample size for males, the differences described above are not statistically solid, and the emphasis in following analyses is on females.

3.4.3 Home Range in Relation to Sample Size

Calculated home range sizes increased with the number of radio-locations upon which they were based up to about the 20-24 locations category, with the greater frequencies of large figures and increasing means to that time (Table 5). However, with standard deviations averaging more than 50% of the means, variation is a more certain feature of the data than is trend.

Since the animals use different areas seasonally, home range figures must be based on observations from all such areas, i.e., over at least one annual cycle, to be even minimally close to an animal's total or lifetime range. The Spatsizi sample included four females each of which were observed in 44-52 locations over four annual cycles since fall 1980. Figure 5 depicts the cumulative increase in range size of those animals both with increasing sample size and the passage of time. Again, individual variation is evident. The proportion of the total (4-year) range identified by the first 25-35% of the observations, after one year, was about 30% for two animals but was about 60-80% for the other two. After two years, in which about 60% of the locations had been identified, an average of 70% of the 4-year range had been defined for three animals, with only a 1% increase in the case of the extreme from the previous year. However, the total range of the fourth was 95% defined by that

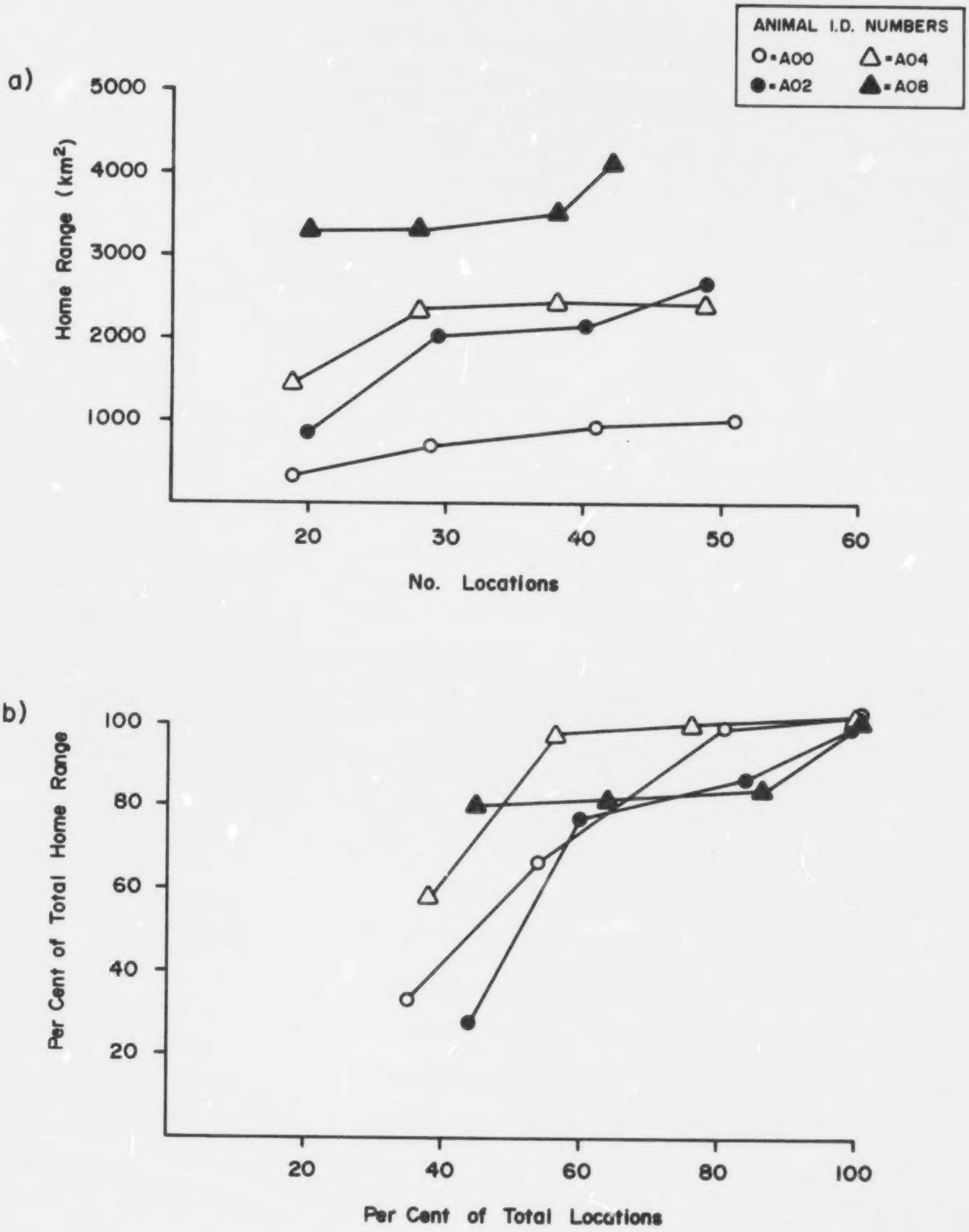
Table 5. Caribou home range size in relation to the number of locations, Spatsizi Wilderness Park area, British Columbia, 1980-1984. Both visual and radio-locations are represented. Cumulative totals for the larger sample sizes are also given.

Sex	No. Locations	No. Animals	Frequency, by home range size (1000 km²)						Home Range (km²)	
			<1	1-1.99	2-2.99	3-3.99	4-4.99	5+	Mean	SD
Females										
	<15	5	2	1	2	-	-	-	1580	942
	15-19	5	1	2	1	-	1	-	2170	1597
	20-24	12	2	-	3	3	3	1	3104	1501
	25-39	4[1]	-	4	-	-	-	-	1369	207
	40+	4	-	1	2	-	1	-	2573	1292
	Cum.(15+)	25	3	7	6	3	5	1	2554	1445
	Cum.(20+)	20	2	5	5	3	4	1	2651	1432
	Cum.(25+)	8	-	5	2	-	1	-	1971	1072
Males										
	<15	3	3	-	-	-	-	-	345	296
	15-19	1	-	-	-	1	-	-	3102	-
	20-24	4	2	2	-	-	-	-	1309	534
	Cum.(15+)	5	2	2	-	1	-	-	1668	926

---

[1] One female, No. B18, had a total range of 11,280 km², which was more than twice as large as the next largest. The 25-39 locations category and cumulative totals do not include that value. Separate calculations including B18's contribution are as follows: Cum.(15+) - Mean 2890, SD 2221; Cum.(20+) - 3061, 2344; Cum.(25+) - 3005, 3261.

Figure 5. Increases in home range sizes of four female caribou over a 4-year period, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. Figure 5a shows absolute cumulative range sizes, calculated at the end of each annual cycle (October) and plotted against the number of radio locations to those times. Figure 5b shows the same data as percentage increases per year, considering the final (4-year) figure as the total home range.


ANIMAL I.D. NUMBERS
○=A00
△=A04
●=A02
▲=A08
a)
5000
4000
3000
2000
1000
Home Range (km²)
20
30
40
50
60
No. Locations
b)
100
80
60
40
20
Per Cent of Total Home Range
20
40
60
80
100
Per Cent of Total Locations

time. At the end of the third year, by which time an average of 82% of all pertinent observations had occurred, two animals' observed total ranges were 99 and 100% defined, while the other two were at about 85%.

Three of the four animals showed roughly steady increases in observed total home range over the four years, with the greatest rates of increase between the first and second years. The other animal, with a larger range in year one than the others had after four, nevertheless showed its greatest increase in the last year.

While Figure 5a treats the data as though the 1984 home range figures actually represent total ranges for the four females involved, that is unlikely to be the case. As shown in Figure 5b, the trend at the end of four years was still towards at least slight increase for three of them. Among the animals captured in 1982, all had larger home ranges at the end of the second year than at the end of the first. The mean percentage increase for 13 females that were tracked at least two full years (Appendix 6) was 90% (SD 107, Range 5-390). Only three had increased home range sizes of less than 35% in the second year.

3.4.4 Home Range in Relation to Age

As an apparent long yearling when captured in fall 1982, No. B17 was the youngest of the collared animals and her observed home range over the following 12 months was 4865 km², a one year total second only to that of chronic traveller No. B18 (9 years old). Overall, there appears to have been a tendency for larger observed ranges, both in the year following capture and subsequently, among the younger females (Table 6). That may indicate more directed movements for the older, more settled

Table 6. Relationship of age to home range size in female caribou, Spatsizi Wilderness Park area, British Columbia, 1980-1984. The data shown are only for animals radio-tracked at least 12 months, and located 15 or more times for Total Range (all years) and 12 or more times for 1st Year Range. Numerical ages are as determined by counts of tooth annuli; other age categories include young adults (YA), believed 1-3 years old and older adults (AA), believed to be at least age 4. Cumulative totals include samples of both known and estimated age, e.g., Cum.(YA) = 1-3 plus YA.

Home Range	Ages	No. Animals	Frequency, by home range size (1000 km²)						Mean	SD	Range
			<1	1-1.99	2-2.99	3-3.99	4-4.99	5+			
Total											
	1-3	5	-	2	1	-	2	-	2904	1726	1202-4865
	YA	4	-	-	3	-	1	-	2856	912	2348-4222
	5-9[1]	3	-	2	-	-	1	-	2155	1752	1010-4172
	10-12+	4	1	-	-	1	1	1	3641	2027	904-5447
	16	1	-	1	-	-	-	-	1303	-	-
	AA	7	2	2	2	1	-	-	1792	928	494-3064
	Cum.(YA)	9	-	2	4	-	3	-	2882	1342	1202-4865
	Cum.(AA)	15	3	5	2	2	2	1	2325	1551	494-5447
1st Year											
	1-3	5	2	1	-	1	1	-	2173	1758	819-4865
	YA	4	1	2	1	-	-	-	1650	605	861-2334
	5-9[1]	3	1	1	-	1	-	-	1603	1544	331-3320
	10-12+	4	-	3	1	-	-	-	1754	725	1205-2822
	16	1	-	1	-	-	-	-	1178	-	-
	AA	7	4	3	-	-	-	-	1017	419	290-1519
	Cum.(YA)	9	3	3	1	1	1	-	1940	1326	819-4865
	Cum.(AA)	15	5	8	1	1	-	-	1341	804	290-3320

---

[1] Figures do not include Animal No. B18; with those data added, the means for the 5-9 and Cum.(AA) categories increase by 2000+ and 550+, respectively (Total Range), and by 2000+ and 500+ (1st Year Range), and SD's approach or exceed the means.

animals, although there was again considerable variation and there can be no statistically firm conclusions.

3.4.5 Annual Variation in Home Range Size

The total area used by an animal over one annual cycle may be determined at least partly by extrinsic factors such as temperature, precipitation, or predator distribution and abundance, all of which may vary from year to year. Table 7 compares home range sizes on an annual basis for all animals radio-tracked for 2 full years or more. The data show a trend to decreasing mean annual ranges over the study period, although again with high variation. In comparison to each animal's first year home ranges, two (12%) had about the same size ranges and five (29%) had larger ranges in 1983-84, the year with the smallest mean home ranges in Table 7. In a comparison of only the last 2 years, when both cohorts were represented, nine (53%) had smaller ranges, two (12%) were the same and six (35%) had larger ranges in 1983-84.

3.4.6 Other Home Range Comparisons

Table 7 also provides a comparison of home range sizes between two cohorts of collared caribou, i.e., those captured in 1980 and those captured in 1982. The 1980 animals had much smaller mean home range sizes in both years for which the comparison can be made. That may be partly an artifact of small sample size for that cohort (only four animals); the largest mean range for the 1980 animals was in 1980-81, when there were seven animals in the sample. The difference in mean range sizes between the cohorts may also reflect the existence of separate subpopulations of animals in the general area, each with distinct

Table 7. Annual and cohort variation in home range size of female caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-84. The year designations are for the 12 month period, November through October. Home ranges for animals with fewer radio locations than the minimum indicated are excluded.

Year	Year Captured	N	No. Locations			Home Range Size (km^2)		
			Min.	Mean	SD	Min.- Max.	Mean	SD
80-81	1980	7	18	20.3	2.1	331-3320	1278	992
81-82	1980	4	8	8.5	1.0	377-1887	913	813
82-83	1980	4	10	11.5	1.9	170-1169	572	487
	1982	18[1]	12	14.1	1.1	290-4865	1652	1076
	Both	20	12	14.0	1.1	290-4865	1584	1042
83-84	1980	4	6	8.5	2.4	204- 470	386	124
	1982	10	8	9.2	1.3	340-3275	1434	969
	Both	12	8	9.4	1.3	204-3275	1246	981

---

[1] No. B18, with an observed home range more than twice as large as any other in 1982-83, was not included in the calculations for that year; in 1983-84 she occupied an area within the statistical range of the others, and was included.

patterns of range use. There appears to be a regular post-rut movement to the northern Spatsizi Park area where, and about at the time, all of the A and B series animals were captured. However, most of the 1980 captures were earlier than those in 1982, possibly focussing to a greater degree on individuals that rutted nearby. The comparisons in Table 8 show animals that rutted and/or calved in the Caribou Mountain area, near where they were captured, maintained the smallest ranges, while those that were found during June through October on other ranges, especially those farther south, had much larger ranges. Generally, the largest ranges were recorded for those with no identifiable rutting or calving range affinities, i.e., those that were found in more than one of the areas listed during the seasons of interest.

3.5 MOVEMENT PATTERNS

3.5.1 General

Appendix 7 provides detailed data on movements of the collared caribou between tracking flights during the study years. Figure 6, which presents data on mean movements per flight, compares seasonal and annual patterns between and among years. The movements data would better be termed "minimum implied movements" for two reasons. First, about 10% of all contacts involved animals that had not been found on one or more previous flights, so that in such cases figures for distance from last location span longer time periods than is the case for figures calculated on the basis of successive flights. For consistency, those observations were edited out of the data set upon which Appendix 7 and Figure 6 are based, but that results in minimizing

Table 8. Relationship of caribou home range size to seasonal range affinities, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. The data are only for females tracked at least two full years, and located at least 15 times.

Activity[1] Range Affinity[2]	N	Frequency, by home range size (1000 km²)						Home Range (km²)		
		<1	1-1.99	2-2.99	3-3.99	4-4.99	5+	Range	Mean	SD
Rut										
Caribou Mtn.	8	1	3	4	-	-	-	494-2625	1756	845
Tomias Mtn.	3	-	-	-	2	1	-	3040-4863	3656	1046
Outliers	3[3]	-	-	2	-	1	1	2348-4510	3083	1236
Multi.	2	-	-	-	-	2	-	4172-4222	4197	35
Calving										
N. Stikine	2	1	-	1	-	-	-	494-2348	1421	1311
N. Spatsizi	3	-	3	-	-	-	-	1010-1284	1165	141
Spatsizi S.	4	-	-	2	2	-	-	2483-3064	2803	293
Laslui S.	3[3]	-	-	1	-	1	1	2390-4863	3627	1749
Other/Multi.	4	-	-	2	-	2	-	2483-4510	3570	1009

[1] Activities: Rut - October locations, Flights 21, 22, 33, 47, 58; Calving - June locations, Flights 16-18, 29, 30, 44, 55, 56.

[2] Areas in which animals were found on the flights listed above:

Rut - Caribou Mountain (uplands north of Spatsizi R. and east of Coldfish Lake); Tomias Mountain (uplands between Ross and Stikine Rivers); Outliers (other than above, including Edozadelly Mountain); Multi. (animals with October locations in more than one of the above areas, different years.

Calving - N. of Stikine R. (Three Sisters Range and points north); N. of Spatsizi R. (Spatsizi Plateau westward, including Eaglenest Range); Spatsizi S. (between Spatsizi R. and Stikine R. headwaters); Laslui S. (Tatlatui Park area); Other (west of Klappan/Skeena Rivers, or east of Stikine); Multi. (more than one calving area recorded.

[3] N and frequency distribution include animal No. B18 (home range 11,280 km²), but statistical range, mean and SD calculations do not.

the apparent extent of movements because a common reason for not finding an animal on a particular flight was that it had moved a long distance.

The other reason why the movements data are minimal is that each represents only the straight line distance between locations on two successive flights. However, the animals usually traveled farther than the distance between those two points, arriving at the second by a route less direct than a straight line, or in some cases, on return from other more distant locations. The greater the time gap between flights, the more likely that the animal made undetected movements and, as shown in both Appendix 7 and Figure 6, there were intervals of two months or more between flights at times, especially in years 2 and 4.

3.5.2 Seasonal Movements

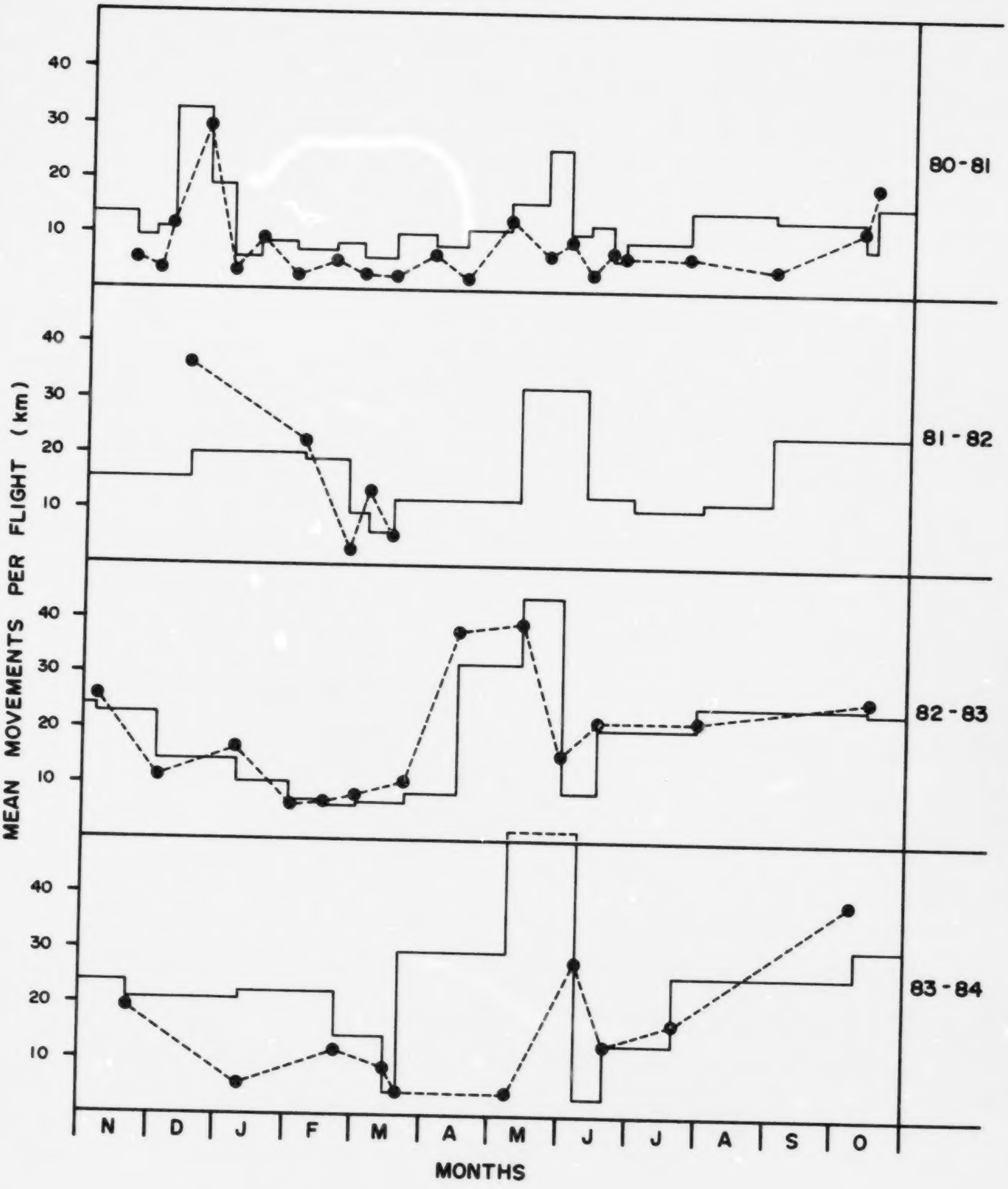
Despite the caveats discussed above, which suggest that the amplitude of movements as portrayed in Figure 6 are probably less than actual, the annual pattern of movements seems fairly clear, especially when considered in conjunction with seasonal distribution data (3.6). The peak movements occurred in May, particularly in the case of most females which dispersed from wintering areas to distant calving areas at that time. The timing of the major spring movement varied somewhat from year to year, apparently depending on weather factors such as residual snowpack. In 1980-81, following a winter of heavy snow, females had moved an average of only 12 km between 16 April and 10 May, while after the mild 1982-83 winter, the average movement during roughly the same time period was 32 km (Appendix 7).

In all years, movements were reduced in June, especially in the case of parturient females, then increased during following months to another, lower peak in October and November as the animals moved first to rutting areas and then to uplands on and near the primary wintering range.

The general trend after November was to decreasing movements, amounting primarily to local wandering on the winter range. That was particularly true in the low snow winters, especially 1982-83. The animals presumably had their greatest potential mobility in that year of lowest snowpack, but their movements between January and mid-April averaged the smallest recorded. The peak of movements in December 1980 (Figure 6), as described in Hatler (1983), followed and was certainly stimulated by an unusually heavy snowfall at that time. During the deep snow winter of 1981-82 the sample of collared animals was small, and flights infrequent, so that if similar movements occurred they were not detected. However, as in 1980-81, large numbers of animals appeared above timberline on Caribou Mountain that winter, and at least some are believed to have moved there from distant ranges. In all years, but particularly in 1981 and 1982, March and early April appeared to constitute the period of least winter movement.

Although the samples were small, the annual pattern for males followed that of females fairly closely, including the snow-induced peak in December 1980, the otherwise generally low incidence of significant winter movement, and the spring peak.

Figure 6. Movements of radio-collared caribou between tracking flights, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. Movements of females are depicted by tops of the solid bars, with their horizontal extent indicating time between flights in relation to the bottom scale. The points and dotted lines represent male movements.


MEAN MOVEMENTS PER FLIGHT (km)
40
30
20
10
80-81
81-82
82-83
83-84
N
D
J
F
M
A
M
J
J
A
S
O
MONTHS

It appeared that males began spring movements somewhat later than females, and they probably moved more than females, especially those with calves, throughout the summer. There is also an indication that the movements of males were more extreme in the fall, especially around rut time, than were those of females (Figure 6, Appendix 7).

3.5.3 Daily Movements

Long intervals between flights have generally obscured the nature of recorded movements, that is, whether they were direct and quick or more divagated and prolonged. Simple division of mean distance moved by number of days between flights indicates that most movements throughout all four study years could have theoretically been accomplished by progress of less than 1.0 km/day (Appendix 8). The primary exceptions to that were during the dramatic December 1980 movement and in May of some years, although the maximum recorded at those times was still just 2.5 km/day. Inspection of Appendix 8 indicates that the speculated long-interval effect is a conspicuous feature of the daily movements data. On 45 flights with greater than a 10-day interval since the previous flight, the mean daily movements figures were equal to or greater than 1.0 km/day on only 8 occasions for females (18%) and 5 times for males (11%). Comparable figures for 9 flights with intervals of 10 or fewer days were 78% for females and 44% for males.

Table 9 lists results for observations separated by 10 or fewer days together with observations from longer intervals in which mean daily movements were nevertheless 1.0 km/day or greater. Even for short intervals, calculated daily movements

Table 9. Daily movements by radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-84. Data were calculated by dividing flight interval into total movements during that interval. All observations at flight intervals of 10 or fewer days and/or flights with calculated daily movements of 2.0 km or more are listed.

Date	Flight Interval (Days)	Daily Movements (km)					
		Females			Males		
		N	Range	Mean	N	Range	Mean
28/11/80	6	5	0.7-2.6	1.6	3	0.3-1.1	0.6
04/11/82	8	2	0.3-1.0	0.7	-	-	-
06/12/80	8	3	0.9-1.8	1.4	3	1.1-1.8	1.5
22/12/80	16	4	1.5-2.6	2.1	1	-	1.9
03/03/82	7	5	0.0-5.4	1.3	1	-	1.9
15/03/84	1	1	-	1.5	-	-	-
17/03/84[1]	2	3	0.8-1.6	1.3	-	-	-
17/03/84[1]	3	2	0.4-0.7	0.6	-	-	-
17/03/84	4	3	0.4-1.0	0.8	1	-	1.0
30/05/81	10	3	1.1-3.8	2.5	2	0.1-1.7	0.9
31/05/83	20	23	0.2-5.6	2.2	3	0.8-2.8	2.0
10/05/84	2	1	-	9.0	-	-	-
10/05/84	3	2	2.0-7.0	4.5	-	-	-
09/06/81	9	2	0.4-1.9	1.1	2	0.1-0.6	0.3
18/06/81	9	6	0.0-6.0	1.3	2	0.5-0.9	0.7
26/06/81	8	6	0.0-2.9	0.8	2	0.6-0.9	0.7
13/06/83	2	3	0.8-2.5	1.8	-	-	-
12/06/84	7	13	0.1-1.4	0.5	4	0.8-2.7	1.9
15/06/84	1	1	-	5.2	-	-	-
21/07/84	1	1	-	9.4	-	-	-
12/10/81	4	7	0.0-3.0	1.9	1	-	4.5
25/10/82[2]	1	-	-	-	4	0.7-3.5	2.5
25/10/82[2]	3	-	-	-	1	-	1.5
10/10/83	1	8	0.5-3.8	2.5	-	-	-
06/10/84	1	1	-	9.2	-	-	-
07/10/84	2	1	-	0.7	-	-	-
08/10/84	3	3	0.5-1.0	0.8	2	0.7-3.0	1.2
09/10/84	4	1	-	0.4	-	-	-

[1] Involves observations at 2- or 3-day intervals during the period 15-21 March.

[2] Animals observed at 1- or 3-day intervals during the period 25 October - 7 November.

were mostly less than 2 km. In two instances, movements between 9 and 10 km were documented between successive days, once in July 1984 and once during rut surveys in October 1984, but there were not many opportunities to monitor actual daily movements. Among calculated daily movements over short intervals, the most consistent longer movements were in May.

During May of 1983, females moved an average of 44 km over a 20 to 21 day period. The range for individuals was from just 3.1 km, for an animal that eventually calved near the wintering area, to 111.5 km. Of 23 females located both on the 10-11 May flight and at the end of the month, 13 had moved more than 40 km. However, the mean calculated daily movement was still just 2.2 km during that period (Table 8). Daily movements are probably more directed and dramatic than that result implies, but the only concrete evidence was obtained in 1984. In that year, three females were contacted both on 7 or 8 May and again on 10 May. One, another female that calved near the winter range, had moved only 3.9 km in 3 days. One of the others moved 14 km during that time (4.7 km/day) and the last moved 18 km in 2 days (9 km/day).

3.5.4 Movements in Relation to Maternal Status

As shown in Figure 6 and Appendix 7, mean movements of females during June and July were less in 1984 than in 1983. That result reflects differential movement tendencies between females with calves and those without, and the fact that there were more successful mothers in 1984 (3.8.2.2). Females with calves moved considerably less than two categories of females without during the summer period (Figure 7). Table 10 shows that although individual variation was rather high, most individuals behaved about as portrayed in Figure 7. During early June, more than 80% of the females with calves moved less than 5 km, while more than 80% of those without calves moved more than that (X^2=10.39, df=1, p<.01). By late July some of the females with calves had made longer movements but most moved less than 10 km and the most frequent single category of movement was 0-5 km. In contrast, both categories of females without calves registered the majority of their movements in the larger (greater than 10 km) movement categories at that time (X^2=3.75, df=1, p<.10).

Females that were known or suspected to have been barren in particular years constituted the most mobile class from early June through October. The smaller sample sizes for barren females in June are because many had made movements so extreme that they could not be located at that time. In that sense, the results indicated in Figure 7 and Table 10 are minimal for them.

Of particular interest is the peak in movements of females with calves in November. That was the only period in which none of that class moved less than 10 km. The long movements were required to bring them back to the areas occupied by other caribou at that time.

3.6 ASPECTS OF SEASONAL DISTRIBUTION

The home range and movements results presented earlier imply considerable dispersion and varying seasonal distribution of the collared animals. Although time and budget constraints did not allow a full analysis of those topics for this report, following sections provide preliminary results for some time periods of interest.

Figure 7. Movements of female caribou as related to maternal status, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. Data are pooled over all years to compare movements between dates shown for females with calves at heel, those known to have lost calves, and those known or suspected to have been barren.

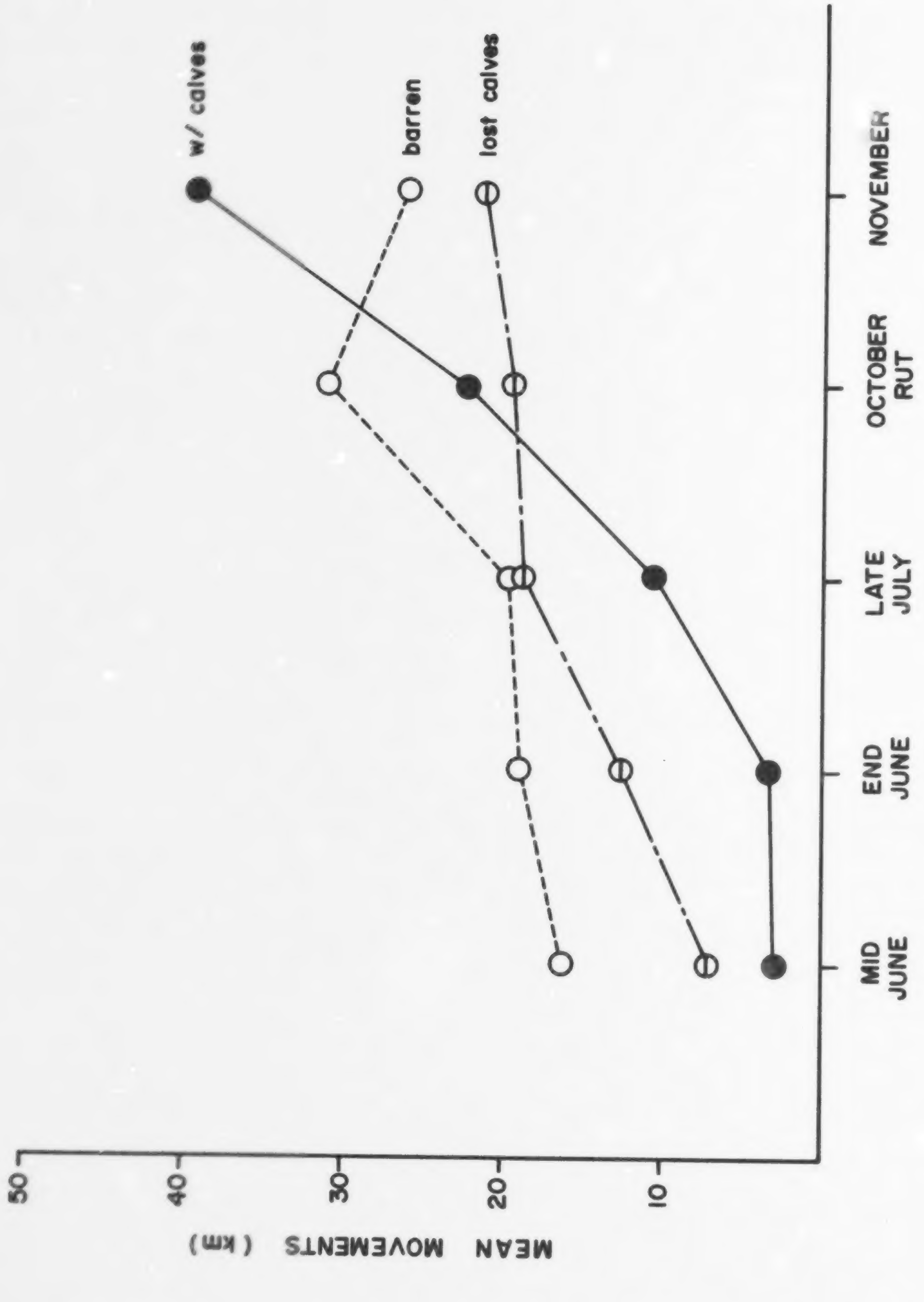

MEAN MOVEMENTS (km)
50
40
30
20
10
MID JUNE
END JUNE
LATE JULY
OCTOBER RUT
NOVEMBER
w/ calves
barren
lost calves

Table 10. Summer-fall movements of female caribou in relation to maternal status, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-84. The three categories of maternal status include females with calves at heel, those that had lost calves, and those known or suspected to have been barren. Movements are since previous date indicated.

Dates[1]		Frequency of Movements (%)					Movements (km)	
Status	N	0-5	5.1-10	10.1-25	25.1-40	>40	Mean	SD
Mid-June								
With	24	83	17	0	0	0	2.6	2.3
Lost	5	20	80	0	0	0	7.3	2.3
Barren	3	0	67	0	33	0	16.1	14.7
End-June								
With	5	60	40	0	0	0	3.8	2.4
Lost	2	50	0	0	50	0	12.4	15.3
Barren	4	25	0	25	50	0	18.9	12.9
July								
With	14	42	21	21	14	0	10.6	10.9
Lost	13	31	0	31	23	15	19.0	17.5
Barren	7	0	14	72	0	14	19.7	10.5
October								
With	9	33	33	0	11	22	22.4	15.6
Lost	21	0	9	62	29	0	19.8	7.5
Barren	9	0	22	22	22	33	31.3	24.7
November								
With	7	0	0	42	16	42	39.9	28.8
Lost	16	6	25	38	12	19	21.7	18.7
Barren	10	20	0	50	0	30	26.1	24.5

[1] Mid-June movements are those recorded between about 1-9 June and 12-18 June during the study years. Other dates: End June (26th-30th), July (20th-29th), October (rut surveys, 5th-12th), November (22nd-28th).

3.6.1 Dispersion

The dispersion of the collared animals on each tracking flight during the last 2 years of study showed marked monthly differences, with similar patterns in the 2 years (Fig. 8). The comparison is based on 90% of the animal locations for each flight, i.e., with the most extreme 10% deleted, and with N=26-29 animals.

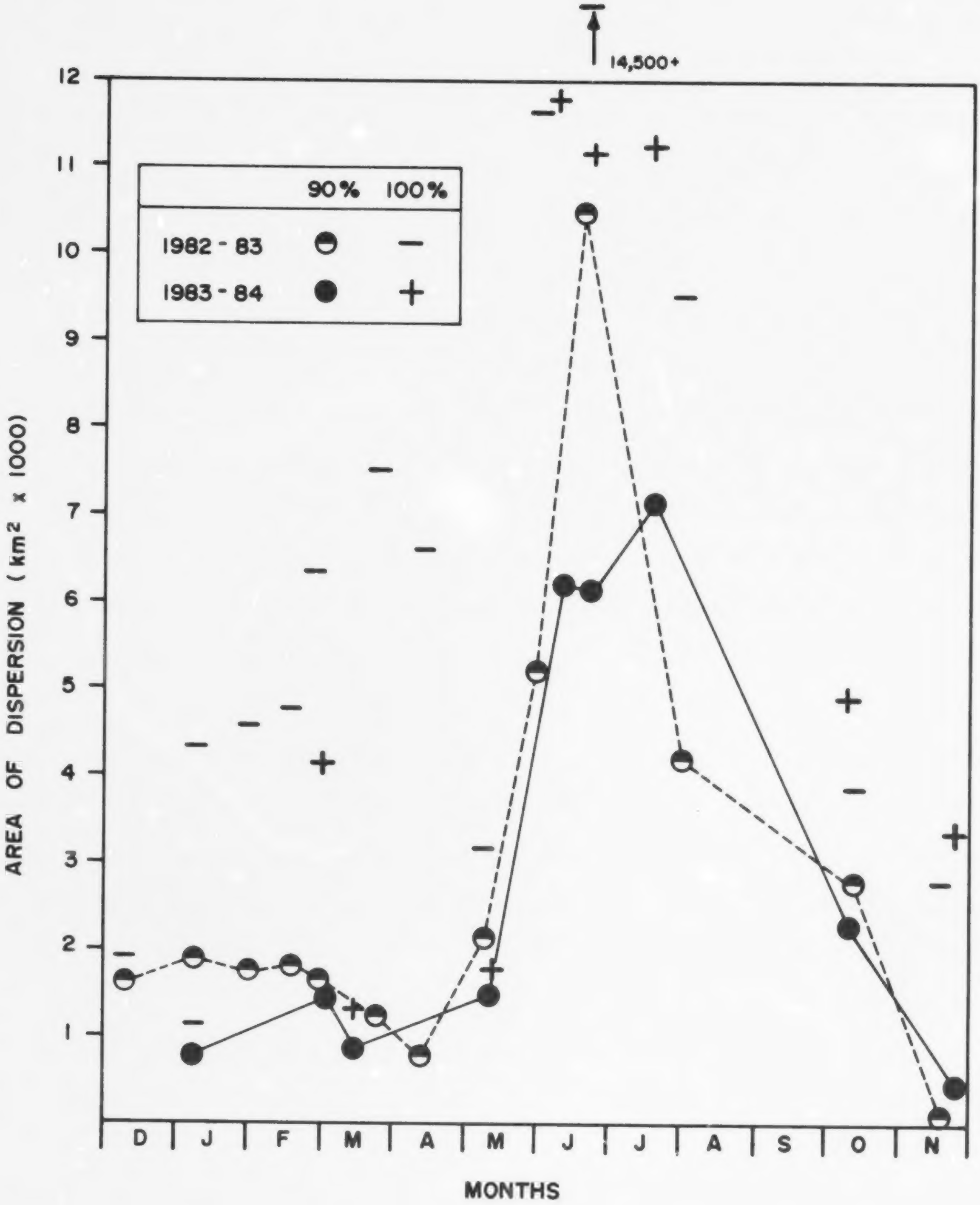
Most of the animals, with numerous uncollared companions, occupied a total area of less than 2000 km² from about December through early May, when their movements were generally small. They then dispersed to an immense area of over 10,500 km² in June 1983 and at least 6000 km² at the same time in 1984. By the time of the October rut surveys in both years, most of the animals had moved back to within an area of less than 3000 km², and by mid-to late November most were contained within an area of less than 500 km² in the vicinity of Caribou Mountain.

The annual pattern indicated may also apply to 1981 and 1982, although the collared sample was smaller in those years. However, there is an indication that the animals may have been relatively more dispersed in winter during the first 2 years, when snow conditions were most severe. The comparable areas of dispersion (km²) in mid-March of 1981-1984, respectively, were: 1979 (N=10); 538 (7); 1235 (26); 927 (24).

3.6.2 Late Winter Distribution

The distribution of caribou in February and March varied annually (Fig. 9). During 1980-1981, when severe snow conditions

Figure 8. Minimum area of dispersion of radio-collared caribou located on tracking flights in the Spatsizi Wilderness Park area, British Columbia, 1983 and 1984. Both the total implied area and the 90% area, after exclusion of the most extreme 10% of the observations, are shown.


14,500+
12
11
10
9
8
7
6
5
4
3
2
1
AREA OF DISPERSION (km² x 1000)
90% 100%
1982 - 83
1983 - 84
D
J
F
M
A
M
J
J
A
S
O
N
MONTHS

developed unusually early, most of the animals moved west and wintered in windblown uplands of the northern Eaglenest Range. One remained with a group of up to 15 on a mountain northeast of Coldfish Lake, and two moved north and wintered in a loose group of about 50 animals in alpine habitat at the headwaters of the Kehlechoa River.

In 1981-82, the winter of heaviest snowfall, there were again scattered groups of caribou, including some of the collared ones on alpine ridges of the northern Eaglenest Range. One of the collared animals eventually moved to alpine habitat on Mt. Sister Mary, north of the Stikine River, after an extensive movement to the west. Others were found at lower elevations in that year, including two in a scattered herd of 30+ in the lower Mink Creek area, another in a group of up to 13 along the Dawson and lower Spatsizi Rivers, one at mid-slope (about 1375 m) west of the Kehlechoa River, and one at lake level (1275) in the Gladys Valley. Both of the latter two animals died, apparently in March, at the locations indicated, as did another in a subalpine valley (1300 m) near Tsenaglode Mountain. A loose herd of over 400 animals, including one collared female, appeared on the windblown uplands of Caribou Mountain in early March of that year.

During the two milder winters, most caribou activity during the February-March period was in mid- to low elevation forests along both sides of the Stikine, from about the mouth of the Pitman River to below McBride River. In particular, the caribou used muskegs and the extensive pine-dominated forest both in the Moose Flats and Cullivan Creek areas on the south side of the

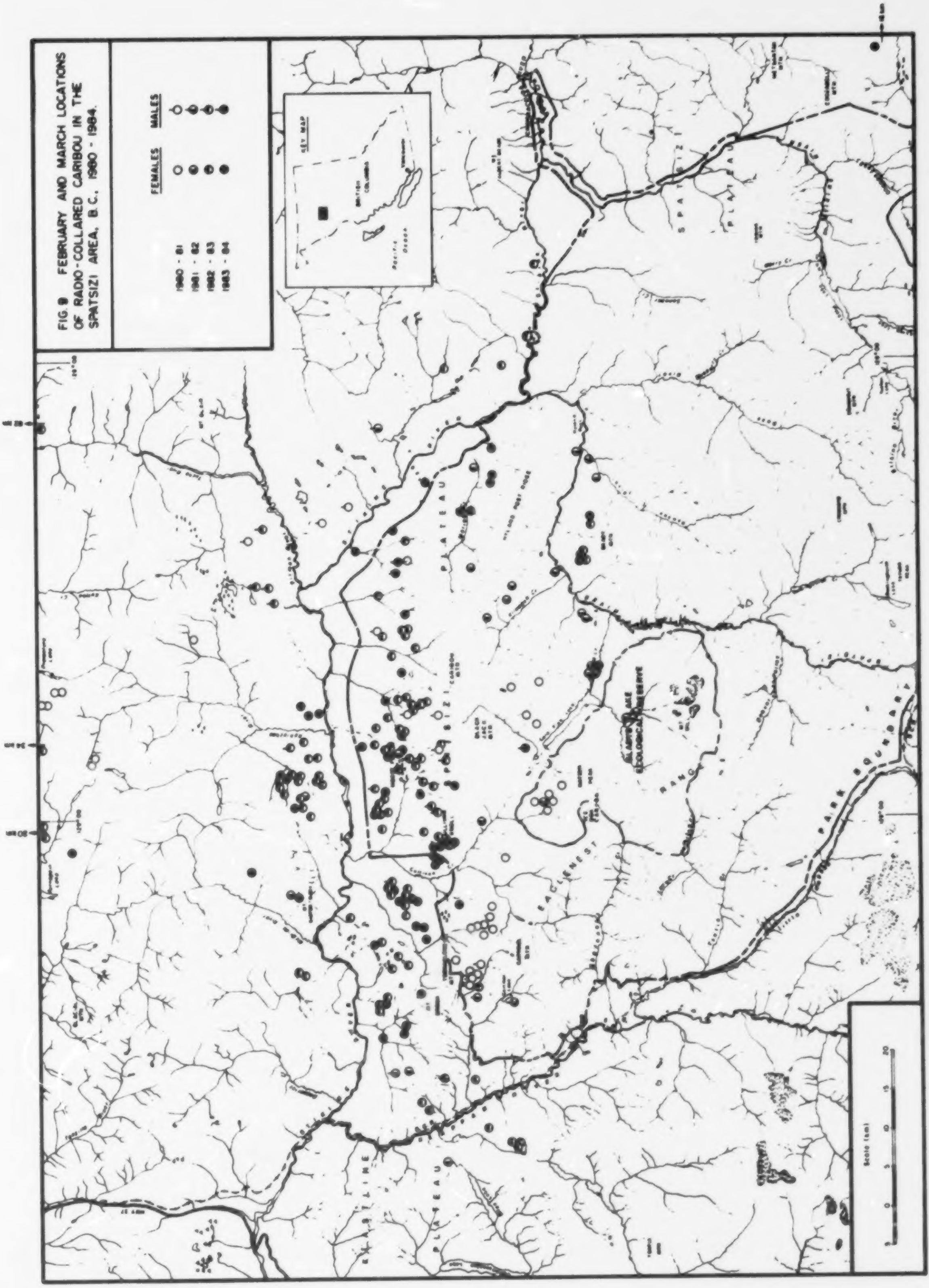


FIG. 9 FEBRUARY AND MARCH LOCATIONS OF RADIO-COLLARED CARIBOU IN THE SPATSIZI AREA, B.C., 1980 - 1984.

FEMALES
MALES
1980 - 81
1981 - 82
1982 - 83
1983 - 84
KEY MAP
BRITISH COLUMBIA
PACIFIC OCEAN
SPATSIZI
PLATEAU
GLADYS LAKE ECOLOGICAL RESERVE
PARK BOUNDARY
Scale (km)
0
5
10
15
20

Stikine and in the Kehlechoa drainage to the north. Although the heavy clustering of locations in those areas provides some visual impact as to the importance of the Stikine forests in winter (Fig. 9), it does not do justice to the heavy tracking observed over extensive areas there during the winters of 1982-83 and 1983-84.

During the late winter period, 95 of 223 locations (43%) were outside of park boundaries. The proportion outside the park was less in the two severe winters (22% of 37 observations in 1981; 25 of 32 in 1982) than in the two mild winters (55% of 111 in 1983; 44% of 43 in 1984).

3.6.3 Early June Distribution

The widespread distribution of caribou in June resulted from extensive dispersal in many directions in May (3.5, 3.6.1). Figure 10 shows locations for both sexes within about one week of the peak of calving (3.8.2.1). For parous females, those locations are at or very near the actual calving sites. Within Spatsizi Park, the mountains in and near Gladys Lake Ecological Reserve and those at the headwaters of the Ross and Dawson Rivers emerge as areas of relatively concentrated use at that time although collared animals were found at many other locations, including points in the drainages of the Nass, Skeena and Finlay Rivers as well as that of the Stikine.

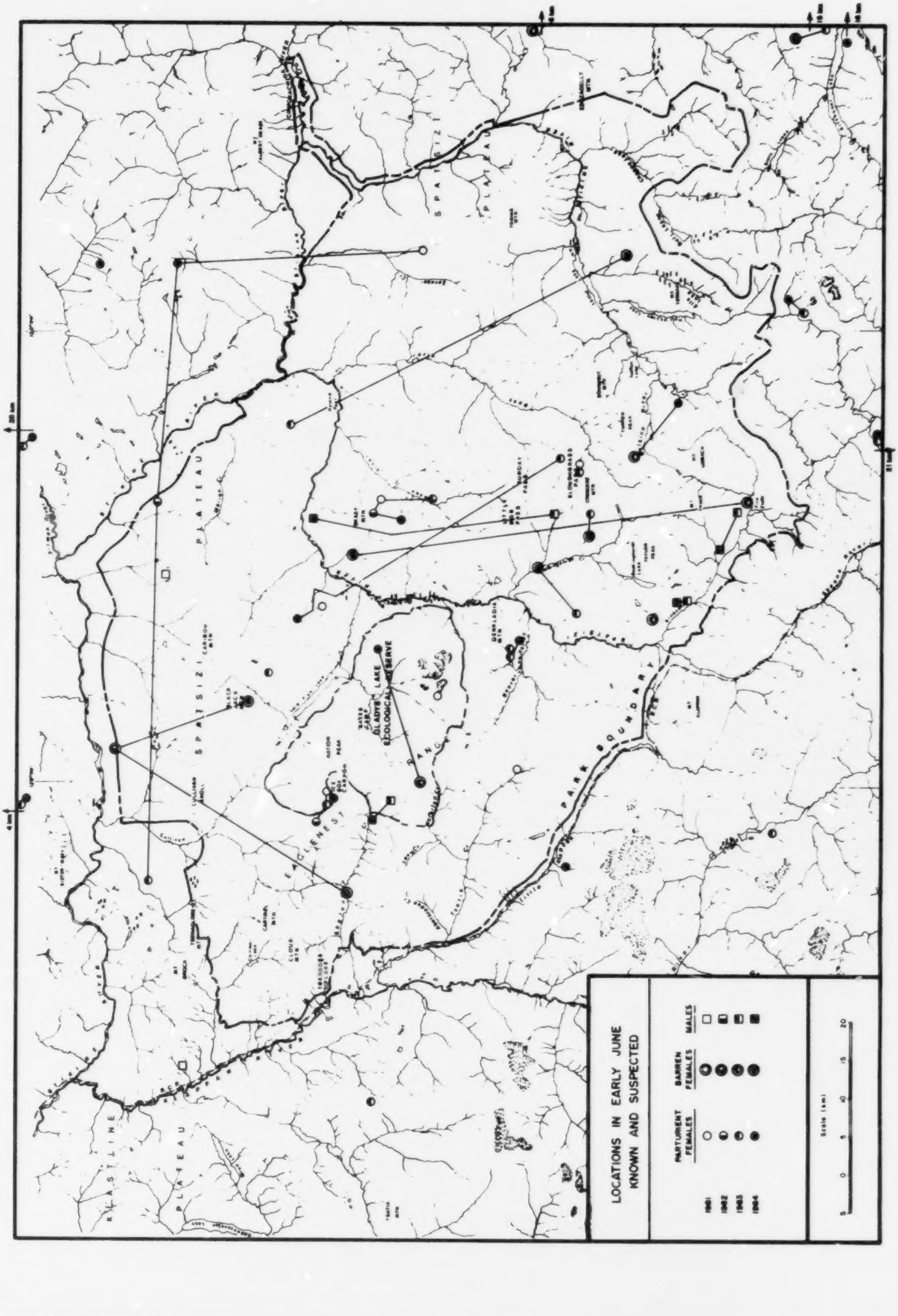
Other caribou were commonly seen during the intensive searches for the collared ones at calving time. If their locations were also plotted, the widespread summer distribution would be even more apparent. All of the animals that appear as outliers in Figure 10, including three females west of the

Klappan River, two off the north edge of the map, two north of the Stikine-Chukachida confluence, and four south of the Spatsizi Park boundary were seen with or near other caribou in June or July. The most extreme location was that of No. B20, found with calves in both 1983 and 1984 in a balsam thicket near the head of a small creek in the Groundhog Range. Although caribou sightings in that area are uncommon and little sign was apparent, No. B20 and her calf were accompanied by three other cow-calf pairs when seen in the same area on 28 July 1983. The distance to the calving location of B20 from her March 1983 location (northeast of Hyland Post) was about 110 km, and was over 125 km from her March 1984 location (north of Coldfish Lake).

Another illustration of the widespread dispersal to calving locations is the case of three females, all captured on 18 March 1984 within an area of less than 2 km^2 north of Coldfish Lake (D cohort in Figure 1). All three calved outside the park, one west of the Klappan River, one north of the Stikine-Chukachida confluence, and the last on the south end of Mt. Rognaas in Tatlatui Park. The three legs of the triangle formed by their June locations were about 104, 102 and 145 km in length.

The proportion of collared animals outside the Spatsizi Park boundaries in early June was 29% (19 of 65). Of those 19, two were inside the adjoining Tatlatui Provincial Park. Among the three classes of animals identified, there appeared to be a differential tendency to occupy areas within Spatsizi Park in early June. Only 1 of 10 males (10%) and 2 of 13 females known or suspected to have been barren (15%) were outside the park

Figure 10. Early June distribution of radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1981-1984. The terms "known" and "suspected" in the legend apply to maternal status (parturient or barren), as described in Section 3.9.2.2. Lines connect early June locations for the same individuals in different years.


LOCATIONS IN EARLY JUNE
KNOWN AND SUSPECTED
1981
1982
1983
1984
PARTURIENT FEMALES
BARREN FEMALES
MALES
Scale (km)
0
5
10
15
20
SPATSIZI PLATEAU
SPATSIZI PLATEAU
GLADYS LAKE ECOLOGICAL RESERVE
EAGLENEST RANGE
PARK BOUNDARY
KLASTLINE PLATEAU
CARIBOU MTN
CLOUD MTN
20 km

boundaries at that time, in comparison to 16 of 42 known or suspected parturient females (38%).

Few of the collared animals were located in the immediate vicinity of known rut concentration areas during early June. Of such occurrences, most were in the northernmost area, near Caribou Mountain. Only one June occurrence of a collared animal was documented in the large Tomias survey area, that on the last day of the month in 1981, and there were no June occurrences on Edozadelly Mountain. Both areas are used more as the summer progresses.

3.6.4 Fall Distribution

Figure 11 shows locations of collared animals found during rut area surveys in all 4 years, i.e., during the period 5-12 October in 1981, 1983 and 1984, and on 27 September in 1982. A few rough locations are also shown, based on the direction of signals that could not be followed to animals because of local weather conditions and/or by inference based on July and November locations. In all years the rut survey areas themselves were covered with sufficient intensity so that all collared animals occupying them were contacted. Thus, animals not contacted at those times were nevertheless known to have been in locations outside of the survey areas.

About two-thirds of the collared animals were found on or near rut survey areas in 3 of the 4 years, but only slightly more than half were in those areas in 1983 (Table 11). In that year, there were relatively few animals, collared or not, on uplands of Tomias Mountain, the rut area usually producing the highest counts; the three collared ones at Tomias were all below the rim of the plateau, at elevations ranging from 1350-1775 m. A number of factors contributed to reduced radio-tracking efficiency in 1983, such that 7 of the 28 collared animals were not even contacted. Among those factors were use of a new pilot, deference of tracking activities to park inventory obligations, and deteriorating weather when the main tracking effort could finally be undertaken. Although the missing animals were not on or near the survey areas, it was unknown whether they were clustered in one or two concentration areas nearby, or were still widely distributed throughout the park area. Observations of the 21 animals that were found suggests that the latter was more likely the case (see Figure 11).

The reason for the different 1983 distribution is not evident. As indicated in Table 11, there were substantially more unsuccessful mothers among the collared sample in 1983 as compared to other years, but based on findings in the other years, that should have resulted in more, not fewer, animals on the survey areas. Local guides (pers. comm.) said that there had been more animals in alpine areas in September, and believed that early snows may have moved them down or caused them to begin the fall migration earlier.

Radio-locating the collared animals at rut time showed that the three rut survey areas are not the only rutting grounds in the park area. While it is true that conspicuous concentrations of animals may normally be found in the survey areas at that time, there is also a proportion of local groups that rut elsewhere. During the 4 years of this study that proportion was apparently highest in 1983. However, in all years collared

Figure 11. Locations of radio-collared caribou at fall rut survey time, Spatsizi Wilderness Park area, British Columbia, 1981-1984. The dates of the applicable surveys were 5-8 October in 1981, 1983, and 1984, and 27 September in 1982. The arrows indicate individual movements between rut survey locations and subsequent locations in the last half of November in 1983 and 1984.

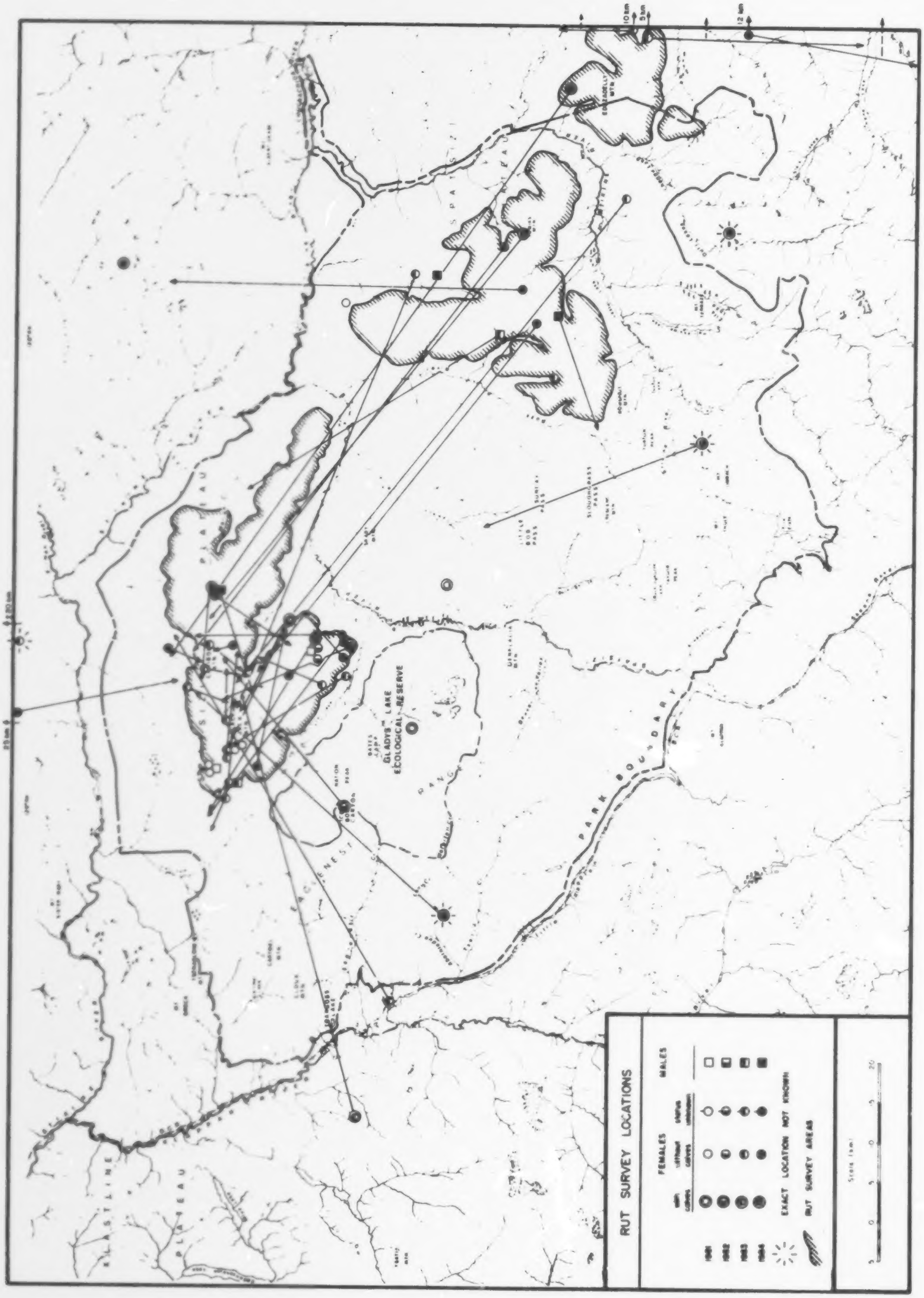

RUT SURVEY LOCATIONS
FEMALES
with calves
without calves
status unknown
MALES
1981
1982
1983
1984
EXACT LOCATION NOT KNOWN
RUT SURVEY AREAS
Scale (km)
GLADYS LAKE ECOLOGICAL RESERVE
PARK BOUNDARY
SPATSIZI PLATEAU
10 km
3 km
12 km
20 km

Table 11. Distribution of radio-collared caribou during rut surveys in the Spatsizi Wilderness Park area, British Columbia, 1981-1984. The survey areas are Caribou Mountain/Marion (C. Mtn.), Tomias, and Edozadelly, as depicted in Fig. 11, but also including downslope areas to surrounding valley bottoms; "Other" includes all locations not within or immediately below any of the three rut survey areas. Status of females refers to their maternal success, i.e., with (C) or without (N) calves at survey time.

	Locations and Status of Females										Locations of Males				
	Rut Survey Areas										Rut Survey Areas				
	C. Mtn.		Tomias		Edoz.		Other		All						
Year	C	N	C	N	C	N	C	N	C	N	C. Mtn.	Tomias	Edoz.	Other	All
1981	0	4	0	1	0	0	2	0	2	5	2	0	0	0	2
1982	0	2	0	0	0	0	1	0	1	2	0	0	0	0	0
1983	1	10[1]	0	2[1]	0	0	1	10[2]	2	22[3]	1	1	0	2	4
1984	2	9	1	3	1	0	4	2[4]	8	14[4]	1	3	0	0	4
All	3	25	1	6	1	0	8	12	13	43	4	4	0	2	10
w/o 1983[5]	2	15	1	4	1	0	7	2	11	21	3	3	0	0	6

[1] Includes one that had a calf earlier, but was not seen in October or later surveys, thus its maternal status at rut was not determined.

[2] Includes one with fall status not determined, and five whose locations during the rut were not known, but were known not to be on the rut survey areas.

[3] Includes three with maternal status not known, as described above.

[4] Includes one seen without a calf in November, but not seen in October.

[5] Total, omitting the results for 1983, when few calves were present and some animals were not seen.

animals located in outlying areas were usually in groups, and usually with at least one bull in attendance. The mean size of nine such groups counted over the 4 years was 21.4 (range 2-70).

Of 57 radio-locations during the rut survey period in all 4 years, nine (16%) were known and one other was suspected to have been outside of Spatsizi Park boundaries. Two others, both females with calves, were not contacted during the rut in 1984. The early summer location of one, No. D41, had been west of the park in the Little Klappan River area, and that of the other (B24) was in mountains near the southern boundary of the park. Thus, both of those may also have been outside the park in early October that year. All of the known locations outside the park involved females. All males actually located concurrent to rut surveys were inside park boundaries. Of 10 possible contacts in that regard, there were eight locations, thus on two occasions (both in 1983), bulls could have been outside the park at rut time.

In previous sections it has been shown that there is a peak in movements following the rut (3.5.2), and by the third week in November the animals are occupying the annual low in dispersion (3.6.1). Figure 11 portrays the direction and extent of those post-rut movements, and shows that the area of post-rut concentration has been in the uplands of the northernmost rut survey area, at Caribou Mountain. From there the animals have direct access to wintering areas documented during this survey, including alpine areas to the west in 1980-81 and 1981-82, and forested lowlands just to the north in the following two winters.

It now appears that for an individual female, the two factors that have the most bearing on her location at rut time are a) her location at calving, and b) her maternal success. Females that have occupied early June areas in the land mass encircled by the Spatsizi, lower Stikine and Little Klappan Rivers have generally rutted at locations, including the Caribou Mountain rut survey uplands, within that area. Females found in June in most areas between the Spatsizi and Upper Stikine River, and possibly including mountains in the upper Skeena drainage, have also rutted in that area, including many in the Tomias rut survey area. There is some indication that females from summer areas in Tatlatui Park and points east of there constitute the members of rutting groups found in that area, including those in the Edozadelly rut survey area.

Females with calves differ in the nature and extent of their summer movements from those without. In the present context, the result is that some females with calves fail to appear in the major fall congregation areas where rut surveys are undertaken, although they may usually be found in small rutting groups within their general summer ranges as described above. Females that have either failed to produce calves or have lost them during the summer have usually appeared on the rut survey area within their respective summer ranges, although some have moved to other summer ranges, usually moving north to do so.

The situation for males is less clear because of the small sample size, but it appears that the relationship between early summer range and the rutting location also holds true for them, with a general pattern similar to that for females without calves.

3.6.5 FIDELITY TO SEASONAL RANGES

Over the four study years, the most obvious occurrence in the seasonal range use patterns of individuals has been the propensity for many females to return to the same calving area year after year. Figure 10, depicting early June locations, also shows locations of individuals in successive years. Of the four females that were tracked over all 4 years, one calved in a small local valley called Ice Box Canyon and another was found in the upper Dawson valley in all 4 years. A third individual, parturient in at least 3 of the 4 years, had widely separated calving locations in the 4 years, although all but one were along the northern edge of the park. The last of the 4-year animals, an old female known or suspected to have been barren in the last 3 years, also showed no particularly localized homing, although she was found in the northwestern portions of the park in each case.

Among the animals whose early June locations were determined only in 1983 and 1984, 8 of the 14 were within at least 5 km of the same location in both years, and 4 were within 1 km. Two others were within 10 km, and only 4 were at distances greater than that (range 18-55 km). The longest distance between June locations was recorded for a young female, known not to have had calves in either year. Only one of those females was known to have produced calves in both the northern and southern summer range areas (3.6.4.3). Males also showed a tendency to return to the same early June areas. Three of four were within 7 km of the same location in the 2 years; the distance between June locations was just over 30 km for the fourth, but those locations were nevertheless in the same general area between the Dawson and Spatsizi Rivers.

The above results suggest that homing to early June locations is a predictable pattern among Spatsizi caribou, especially in the case of parturient females. Results for 1985 and 1986 (Hatler, unpubl. data) greatly strengthen that conclusion.

Given the early June homing tendency and the observed movement patterns of females, especially those with calves, it follows that there is also a moderate fidelity to general summer and rut areas (3.6.4.3). The post-rut movement to and congregation in the Caribou Mountain uplands implies that, at least for the collared sample, there may also be a fairly strong homing tendency to that location at that time. Data on successive winter locations for individuals have not been analyzed, but the impression is that the animals may be less faithful to particular areas in that season than at any other time.

3.7 SEASONAL AND ANNUAL VARIATIONS IN HABITAT USE

3.7.1 General

Considering habitat broadly, following sections describe the distribution of collared animals and their companions at different elevations, on slopes facing different directions, and in different vegetative cover types during the various seasons over the 4 years of study.

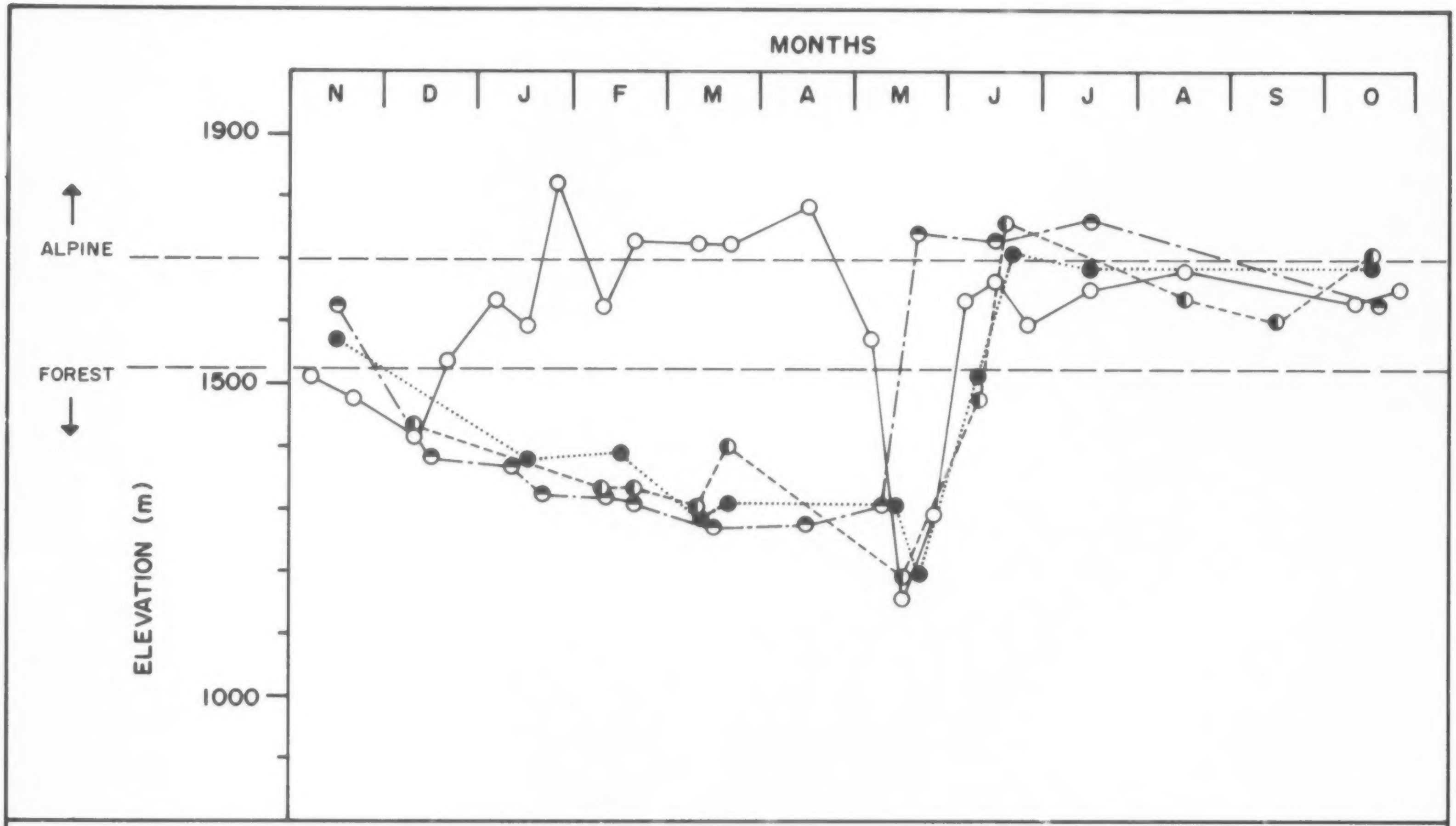
3.7.2 Elevation and Aspect

3.7.2.1 Elevation - Figure 12 depicts the altitudinal distribution of radio-collared female caribou over four annual cycles beginning in 1980. Appendix 9 lists minimum and maximum values together with means and standard deviations for both sexes on all flights through 1984. The general pattern was a gradual descent from about 1500-1600 m in November to about 1300-1400 m for most of the winter and spring, through April, followed by a drop to the lowest mean elevation of the year, under 1200 m, in May (Fig.12). Females then moved upslope in late May - early June, occupying areas as high as 2150 m in June through July, but averaging about 1700-1750 m during those months in 1982-84 and about 100 m lower in 1981. As shown in Figure 12, the animals generally dropped to somewhat lower elevations in late summer and fall, averaging about 1600 m, and the descent to winter areas began again in about November.

Figure 13 plots elevations of all individual collared females encountered on tracking flights during May through July of the four study years. It confirms that most of the animals were in lowland, forested habitats in May, and shows that although there was a definite upward trend after May, many females remained below timberline through the peak of the calving period in early June. That was particularly true in 1983 while in 1982 most were above 1600 m by 1 June. At least some animals were found below 1500 m throughout the period shown, but by late June and on through July, most were well above that level.

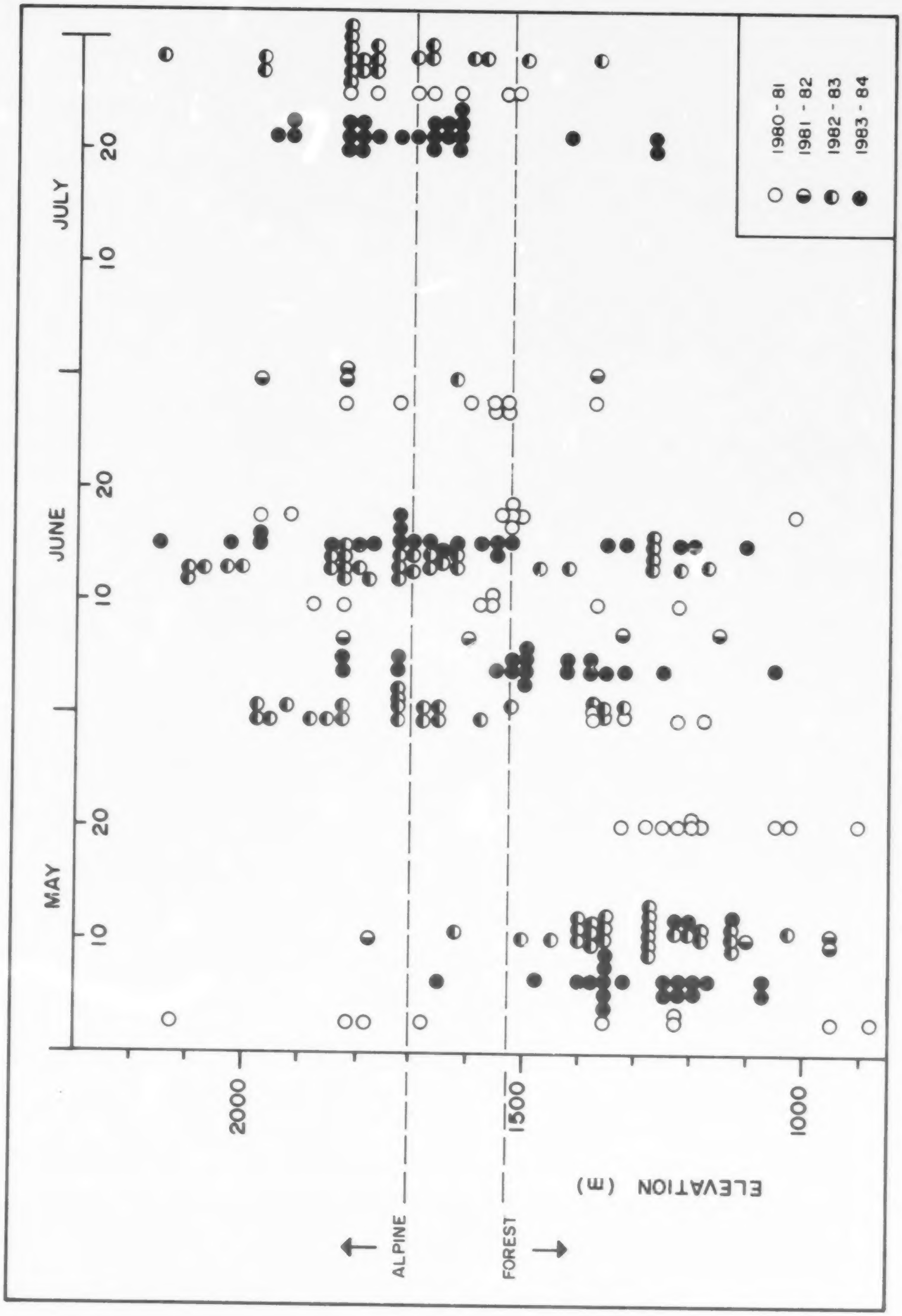
Based on the smaller sample for males (Appendix 9), the winter pattern was similar to that of the females except in 1981, when the females remained higher on average. Like the females, the collared males moved down to their lowest seasonal ranges in late April - early May, but unlike the females they tended to

Figure 12. Elevation of radio-collared female caribou recorded on 58 tracking flights, 1980-1984, in the Spatsizi Wilderness Park area, British Columbia. Each plotted point is the mean observed on one flight.



SYMBOLS		SAMPLE SIZES											
○	1980 - 81	6, 7, 5	5, 5	7, 7, 7	7, 7	7, 6	6	7, 8, 3	5, 6, 6	6	6	-	7, 7
◐	1981 - 82	-	5	-	6, 5	5, 6	-	4	4, 4	-	3	3	25
◒	1982 - 83	2	22	21, 22	23, 23	22	23	23, 19	27	18	-	-	26
●	1983 - 84	21	-	5	21	22, 12	-	18, 3	15, 20	22	-	-	29

Figure 13. Altitudinal distribution of radio-collared female caribou in spring and early summer, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. Each point marks the elevation of an individual on the date indicated.


MAY
JUNE
JULY
10
20
10
20
10
20
ELEVATION (m)
2000
1500
1000
← ALPINE
FOREST →
○ 1980 - 81
◐ 1981 - 82
◐ 1982 - 83
● 1983 - 84

remain in those lowland areas through June. By July they had moved back into the uplands at elevations roughly equal to those of the females, and the altitudinal distribution of the two sexes then remained essentially coincident for the rest of the year.

3.7.2.2 Aspect - Although many locations occupied by caribou were relatively flat, all were considered to have some degree of slope in a watershed sense, as portrayed relative to the 30 m (100 ft.) contour interval on flight maps. Slightly more than half of the locations where radio-collared caribou were found during the four study years were on north slopes, about 35% were on south-facing slopes, and fewer than 20% were facing either east or west (Appendix 10).

Figure 14 depicts the direction-of-slope data to compare monthly and annual differences. Combining female data for all years, the highest frequency of occurrence was on north slopes in all months except June, although there was some variation to that pattern in some years. For example, there was an equal or much higher use of south-facing slopes during the first two (deeper snow) winters, and an equal or greater use of north slopes in June following those two winters. Use of east or west slopes did not predominate in any of the 48 months pertaining here, but the most uniformly equal distribution on all four slope directions was during the summer and fall months (June through October). During winter, occurrences were more strongly clumped on north and/or south slopes.

The sample for males is too small to compare annual differences, but the combined data over all years show an essentially parallel directional distribution to that of females during winter, but with greater use of south- and west-facing slopes from April through June. The month with the most equal use by males of all four slope directions was October. As was the case for females, males were not found on east- or west-facing slopes most often in any month (4-year combined data).

3.7.3 Vegetative Cover

Combining the data for all four years, Table 12 shows that coniferous forest was the most commonly occupied broad habitat type during the study. Open alpine habitats ranked second, and the combined occurrence in alpine and subalpine shrub habitats was exactly equal to forest occurrence for both sexes. The other three habitats listed accounted for a total of only 7% of all occurrences, and all consisted of relatively small openings within forested areas. That result confirms the general picture implied in Figure 12, that most locations below about 1525 m were in forest cover.

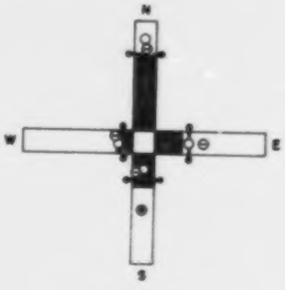
Appendix 11 lists monthly and annual frequencies of occurrence in the habitats listed in Table 12. Those data also confirm the pattern implied by the elevation data (Figures 12 and 13), showing the heaviest use of forested lowland habitats in the winter months and movement to open alpine areas in summer, but with predominant occurrence in the subalpine shrub type in late fall-early winter, especially in November. Variations between years are again apparent, with the animals using alpine habitats after a heavy snowfall in December 1980, but remaining primarily in conifer cover during the last two (low snowfall) winters.

Figure 14. Monthly and annual differences in direction of slope occupied by radio-collared caribou in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. The shaded portion of each direction bar (N,S,E,W) represents the per cent of observations on the slope facing the direction indicated (females only, all years combined). Figures in parentheses after month are sample sizes (females/males) over all 4 years.

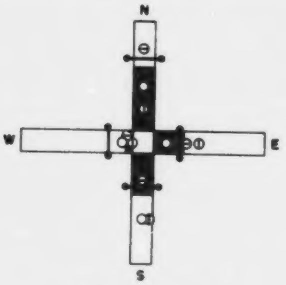
Circles indicate percentages for individual years (females only) as follows:

1980-81 = ○
1981-82 = ⦶
1982-83 = ⊖
1983-84 = ⊕

The symbol ●——● indicates the per cent of observations for males, all years combined.



NOVEMBER (46/21)



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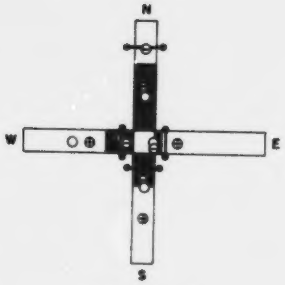

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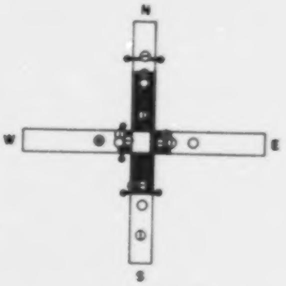

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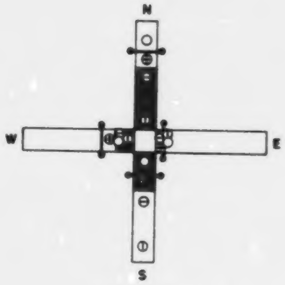
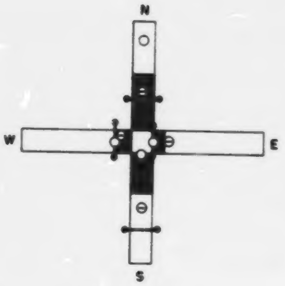
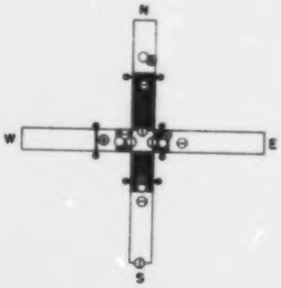


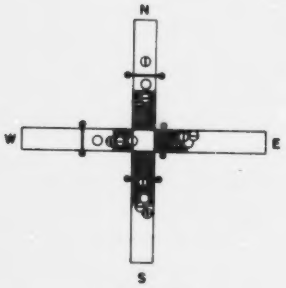
MARCH (80/14)



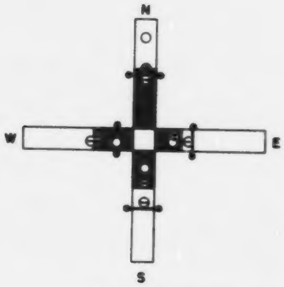
APRIL (29/6)



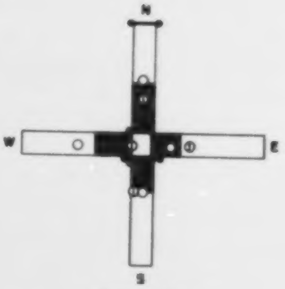
MAY (75/12)



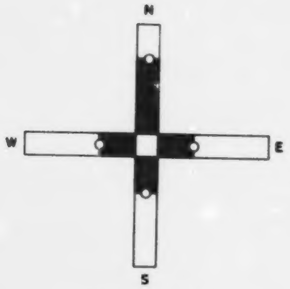
JUNE (98/18)



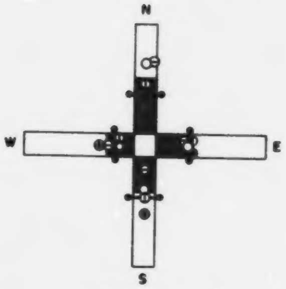
JULY (46/6)



AUGUST (9/1)



SEPTEMBER (3/0)



OCTOBER (82/16)

Table 12. Habitats occupied by radio-located caribou in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-84. The data are from all contacts when the animals were seen and/or the signal was clearly from the habitat indicated.

Habitats[1]	Occurrences, All Four Years					
	Females		Males		Both Sexes	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
Alpine	215	31.2	44	31.9	259	31.3
Subalpine Shrub	106	15.4	19	13.8	125	15.1
Forest	322	46.7	62	44.9	384	46.4
Lowland Shrub	15	2.2	2	1.5	17	2.1
Lowland Herb	5	0.7	6	4.4	11	1.3
Other	27	3.9	5	3.9	32	3.9
Total Sample	690		138		828	100.0

[1] Habitats: alpine - herbaceous or bare ground above 1700 m; subalpine shrub - mostly dwarf birch/willow, but often with scattered sparse conifers, especially subalpine fir--below 1700 m, but above timberline; forest - predominantly tree-covered, mostly conifers; lowland shrub and lowland herb - relatively open habitats (bogs, river bars, meadows) below timberline; other - habitats not included above (burns, frozen lakes/rivers, etc.).

The heaviest use of non-forested, lowland habitats ("other" in Appendix 11) was in April and May, when the animals were seeking new green growth in bogs, riparian areas and open meadows. Female caribou were found in all habitats in June, but the use of alpine areas predominated in most years at that time, especially later in the month. A more detailed account of calving habitats is presented below. In October, during the rut period, alpine and subalpine shrub areas were the main habitats used, with the former predominating in 3 of 4 years, and overall. There were usually at least a few occurrences in forest cover at that time, however.

3.7.4 Calving Habitat

June locations were among the most variable in terms of elevation and aspect, and therefore also in habitat. Appendix 12 lists habitat details for pertinent observations of the collared females during the calving period, i.e., late May through early June, of each of the four study years. Females known or suspected to have had calves averaged slightly higher elevations than other females in early June, although variability within classes (SD) exceeded the indicated differences (Table 13). The two categories of females were found both above and below timberline, on several slope exposures and in different cover types in all 4 years. Parturient females were found on south-facing slopes more often than on any other, but south-facing sites nevertheless constituted fewer than 50% of the occurrences over all 4 years. Likewise, fewer than 50% of the occurrences were at or above the alpine/subalpine ecotone (about 1700 m).

There is some evidence for differences between years. The best comparison is between 1983 and 1984, when sample sizes were largest and climatic differences were great. Following the mild, low-snowfall winter of 1983, spring arrived early. By 31 May the snowline was at about 1525 m and, although there was still more than 50% snow cover above 1675 m, there were open (snowfree) leads on most slopes. Only a few scattered patches remained on Fire Flats, near the western boundary of Spatsizi Park. In that year the animals presumably had the widest choice of snowfree sites for calving, and their selections composed the highest average elevation during the study years, with the greatest combined use of alpine and subalpine shrub habitats.

By contrast, despite a similarly mild winter in 1983-84, April and May remained cold and spring 1984 was phenologically well behind 1983 at the beginning of the calving period. On 4 June, snow cover above 1500 m was nearly 100%, and was in patches constituting more than 50% cover in many lower areas, especially on north slopes. Fire Flats was still snowbound except for the lowest 8-10 km. Surveys in June 1984 found the highest recorded use of south-facing slopes (60%) and sites below timberline (47%) during the 4 years of study, although those differences were not statistically significant (1983 vs. 1984: Aspect - $X^2 = 0.09$, df=1, p<.80; Elevation - $X^2=0.42$, df=1, p<.70). Selection of varying calving habitats was the major feature of the results over the climatic range observed during the study.

The most commonly used forested habitat was in thick, short subalpine fir, either in large continuous stands on north slopes or in "krummholz" patches elsewhere. Animals occupying such habitats were difficult to find even with the telemetry equipment and helicopter. Fewer than 20% of the June calf occurrences were below 1500 m (Table 13). The lowest site recorded was in 1983, when Animal A08 was found with a small calf at 1250 m in thick conifer cover west of Cullivan Creek. On 14 June 1984, a freshly shed female antler was found at 1025 m in a black spruce muskeg beside the Stikine River, a finding that suggests that at least some calving may occur at even the lowest elevations in the study area.

The June locations were considered to be at or near actual parturition sites by the presence of very small, still reddish-colored calves and/or by continued presence of a parturient female in a small area over a several day period (Appendix 12). In some cases, cow/calf pairs were not seen until the calves were older and more mobile. Sites described for those animals (Appendix 12) may not be the actual calving locations, thus biasing the data summarized in Table 13. Comparisons within years indicate that the most likely bias is against lower elevations and forested habitats. The general tendency for animals to move up after May has been shown previously (3.7.2.1). Considering only females with calves, of 13 contacted both in early and mid- or late June, 10 (77%) had at least maintained elevation between the two surveys, and 5 (39%) had climbed more than 100 m. Of five females that lost calves during the same period, one descended 300 m and the other four all moved farther upslope (50-325 m). Overall, no more than 4 of the 18 movements documented in June were downhill (p =.015, Binomial Test, Siegel 1956).

Table 13. Features of habitats occupied by radio-collared caribou during the calving season, late May through mid-June, in the Spatsizi Wilderness Park area, British Columbia, 1980-1984. The two maternal status categories involve females known or suspected to have had calves (Calf), and those known or suspected barren (None). Among the frequency categories, U indicates unknown, the letters under aspect are the four cardinal directions, and the numbers 1-5 under habitat are alpine, subalpine shrub, forest, lowland shrub, and other, respectively.

Year		Elevation (100 m)						Aspect					Habitat (Cover)					
		Frequency (%)						Frequency (%)					Frequency (%)					
Status	N	<15	15-17	17+	U	Mean	SD	N	S	E	W	U	1	2	3	4	5	U
1981																		
Calf	7	29	14	29	29	16.26	2.04	0	43	43	14	29	29	29	14	0	0	29
None	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982																		
Calf	3	33	33	33	0	15.83	2.50	67	33	33	0	0	33	33	33	0	0	0
None	1	100	0	0	0	11.50	0	100	0	0	0	0	0	0	0	100	0	0
Both	4	50	25	25	0	14.75	2.98	75	25	0	0	0	25	25	25	25	0	0
1983																		
Calf	18	11	11	44	33	17.16	2.01	22	39	11	11	27	44	11	22	0	0	22
None	5	0	20	60	20	17.88	1.49	40	40	20	0	20	60	0	0	0	20	20
Both	23	9	13	48	30	17.34	1.87	26	39	13	9	26	47	9	17	0	4	22
1984																		
Calf	15	13	40	47	0	16.68	1.96	27	60	20	20	0	53	0	47	0	0	0
None	5	20	60	20	0	15.15	1.87	20	40	20	40	0	20	0	40	0	40	0
Both	20	15	45	40	0	16.33	2.05	25	55	20	25	0	45	0	45	0	10	0
All Years																		
Calf	43	16	23	42	19	16.73	2.02	23	46	21	14	16	44	12	30	-	-	14
None	11	18	36	36	9	15.88	2.55	36	36	18	18	9	36	-	18	9	27	9
Both	54	17	26	41	17	16.54	2.14	26	44	20	15	15	43	9	28	2	6	13

3.7.5 Post-Calving Habitat

Since previous studies had suggested that Fire Flats, along the south boundary of Spatsizi Park, is a post-calving area used by a representative proportion of the Tomias Mountain rutting "herd" (Bergerud *et al.* 1984b), observations of collared animals in that area are of interest. During the 4 years of radio-tracking, collared animals were located on or near Fire Flats on only nine occasions. Five of those involved bulls B29 and C39, both present in 1983 and 1984. The only parous female documented in the Flats was No. B20, found passing through on 31 May 1983 enroute to her calving site in the Groundhog Range. The other females were: B12, a 17-year-old barren female; No. B14, an older female that stayed in the mountains as a successful mother in 1983, but visited the Flats in 1984 when she was barren; No. C38, a nulliparous female, probably two years old when captured and collared on the Flats in 1983. Three females that have had calves within 15 km of the Flats (B19 twice, B24, B10) are not known or suspected to have ever taken them there.

3.8 SEASONAL AGGREGATION PATTERNS

Figure 15 shows seasonal changes in mean caribou group size and Table 14 provides details on sample sizes, statistical variation, and frequency of particular group size categories observed during the study. The most consistent result is for the late May through mid-June period, when mean group size was at the annual low of just 2-3 animals, and more than 90% of all groups seen were in the smallest group size category (1-5). By the end of May, most females appear to be alone, although occasional small groups (2-5) were seen together at that time. The most

Figure 15. Caribou group sizes observed on radio-tracking and census flights in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984.

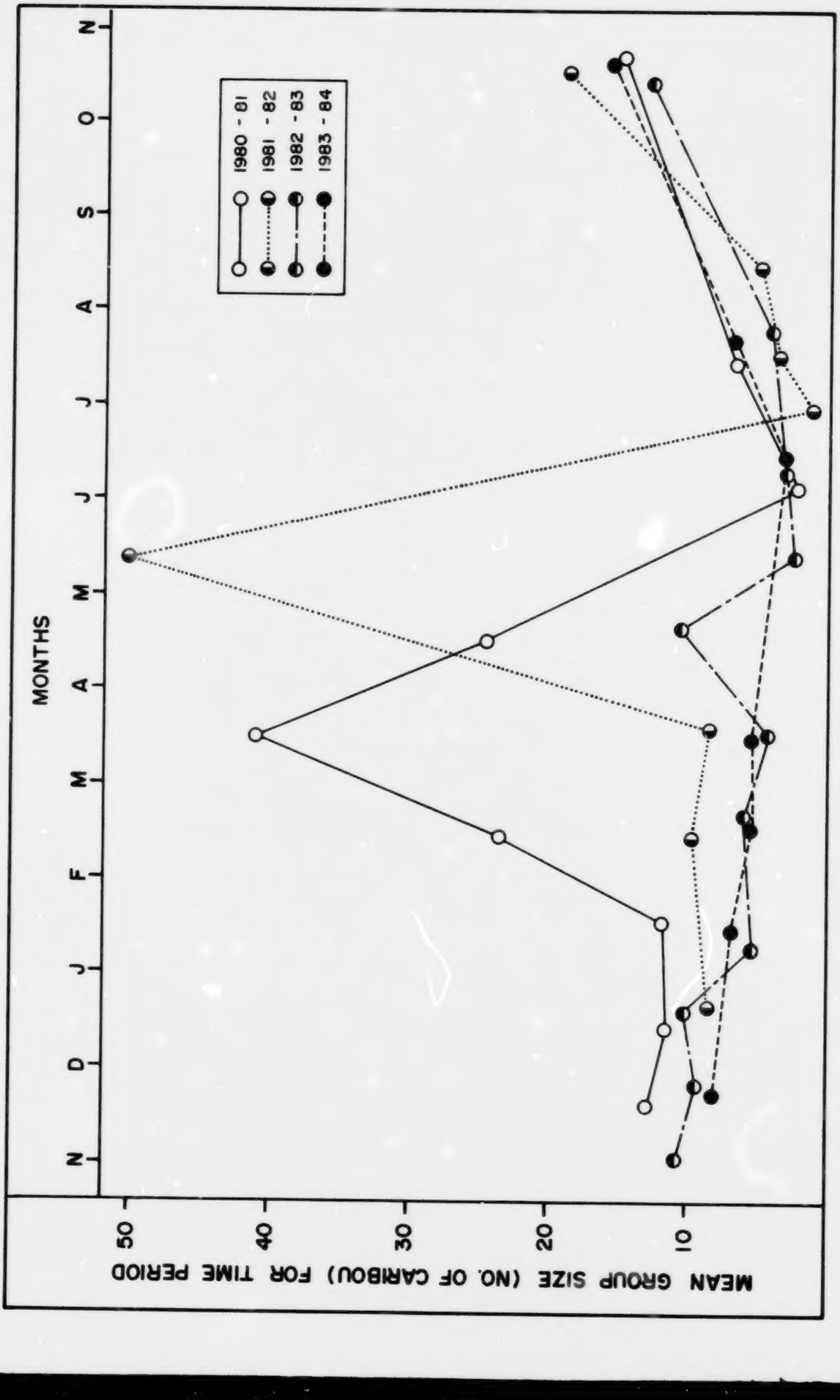

MEAN GROUP SIZE (NO. OF CARIBOU) FOR TIME PERIOD
10
20
30
40
50
MONTHS
N
D
J
F
M
A
M
J
J
A
S
O
N
1980 - 81
1981 - 82
1982 - 83
1983 - 84

Table 14. Seasonal group sizes among caribou observed during radio-tracking and census flights, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-84. The time periods indicated have particular biological significance (e.g., calving or rut periods) and/or reflect the distribution of tracking flights; years in which there were no flights during a particular period are not listed. Data under group size frequencies are percentages, based on the N groups listed.

Time Period	Group Statistics				Group Size Frequencies				
Year	N	Range	Mean	SD	1-5	6-10	11-25	26-50	>50
21/10-15/11									
1980	43	1-75	14.6	16.9	28	33	26	9	4
1982	99	1-41	10.0	6.6	26	32	38	3	0
16/11-30/11									
1980	9	2-48	12.6	14.3	33	33	22	11	0
1983	2	5-11	8.0	4.2	50	0	50	0	0
1984	26	2-24	9.9	6.0	19	50	31	0	0
01/12-31/12									
1980	5	5-25	11.8	8.4	40	20	40	0	0
1981	6	5-15	8.2	3.9	33	50	17	0	0
1982	6	3-27	10.3	9.6	50	17	17	17	0
01/01-31/01									
1981	45	3-43	11.9	10.0	33	24	27	16	0
1983	34	1-12	5.6	3.0	53	38	9	0	0
1984	3	1-14	7.0	6.6	33	33	33	0	0
01/02-28/02									
1981	20	1-100+	23.6	25.6	20	15	30	25	10
1982	18	1-32	9.6	8.1	33	33	22	11	0
1983	31	1-21	6.0	5.4	61	29	10	0	0
1984	7	2-18	5.9	5.6	72	14	14	0	0
01/03-31/03									
1981	10	4-100+	40.9	34.0	10	0	30	40	20
1982	60	1-47	9.0	9.1	50	22	20	8	0
1983	25	1-17	4.1	3.4	76	20	4	0	0
1984	32	1-20	5.2	4.1	69	25	6	0	0
01/04-15/04									
1981	20	3-80	24.2	21.5	15	25	20	25	15
1982	1	50+	50+	-	0	0	0	0	100
1983	26	1-47	4.7	8.8	85	11	0	4	0
16/05-21/06									
1981	14	1-5	2.0	1.2	100	0	0	0	0
1982	1	1	1.0	-	100	0	0	0	0
1983	60	1-8	2.8	1.8	93	7	0	0	0
1984	38	1-11	3.0	2.3	92	5	3	0	0

Table 14 (continued)

Time Period	Group Statistics				Group Size Frequencies				
Year	N	Range	Mean	SD	1-5	6-10	11-25	26-50	>50
22/06-31/07									
1981	12	1-28	6.3	7.9	75	0	17	8	0
1982	9	2-9	3.9	2.3	78	22	0	0	0
1983	20	1-11	4.0	3.4	75	20	5	0	0
1984	60	1-55	7.4	10.2	62	20	13	2	3
01/08-21/09									
1981	7	1-6	3.4	2.2	71	29	0	0	0
1982	9	1-14	5.2	4.4	67	22	11	0	0
22/09-20/10									
1981	36	1-70+	18.4	19.3	39	14	17	27	3
1982	149	1-85	12.6	13.9	39	21	28	29	3
1983	55	1-60+	15.8	15.5	38	13	25	22	2
1984	76	1-87	17.1	19.6	33	25	17	16	9

common groupings during the first half of June were cow/calf pairs, small groups of unsuccessful cows, and small groups of bulls.

It is apparent that most cows with calves move little for up to 10 days following birth, and possibly longer. Group sizes gradually increased thereafter, with neighbouring cow/calf pairs often joining together into small maternal bands, of which the largest seen was a group of six cows and six calves on 20 July 1984. Barren females, including yearlings, and those that lost calves also join groups of cow/calf pairs, but most appeared to gravitate away from the calving areas as summer progressed, forming into somewhat larger groups that included bulls. Overall, however, observed groups remained small throughout the summer, with more than 80% consisting of 10 or fewer animals through August.

There were few September observations, but by October the consistently largest and among the most variable group sizes of the year had gathered for the rut. Single groups in excess of 100 were observed on reconnaissance flights at that time (G. Jones, pers. comm.), but the largest recorded on actual surveys during the 4 years of this study was 87 on Tomias Mountain in October 1984. October was the only month when one or more groups numbering 26-50 animals was seen in all 4 years. However, the predominant group size category in that month, as with most of the others, was 1-5, averaging just under 40% of the observations (Table 14).

After the rut, group sizes generally diminished from means of 12-18 animals down to 8-10 animals by November. The trend after that in the low-snowfall winters (1982-83 and 1983-84) was to continued small group sizes, averaging only 4-6 animals through March. The greatest differences in a comparison between years (Figure 15, Table 14) are in the late winter-early spring period. Following the abnormally heavy snow in December 1980, the animals actually increased group size through March and maintained a mean group size higher than in other years through April. The largest groups observed during this study were 100+ together on Blackjack Mountain on 16 February 1981 and 100+ strung out along a ridge west of Bug Lake on both 17 and 29 March 1981.

The results shown in Figure 15 and Table 14 for the severe winter of 1981-82 are somewhat misleading. That is due primarily to small sample sizes and decreased frequency of visits in that year. Following heavy snows in January, group sizes did stay larger through March than was the case for the two low-snowfall winters, but were not nearly as high as in 1980-81. The extremely high mean group sizes indicated for late winter 1980-81 are due mostly to the groups of 100+ mentioned earlier. The Blackjack group was all that remained of a scattered herd that, when seen a month earlier, had consisted of 199 animals in 24 groups (3-31 animals per group). A similar herd seen in 1981-82, also in the Caribou Mountain uplands, included 281 animals in 39 groups (1-47 per group). It seems almost a certainty that if that large scattered herd had been observed over several days, the groups would have joined and split repeatedly such that totals of 100+ or perhaps even the entire total might have been seen together at least once. It seems apparent that group size increases in deep snow winters, as a result of the animals concentrating in the relatively smaller areas where they can best subsist.

The highest mean group size shown in Figure 15 involves a single sighting of 50+ animals seen in alpine habitat north of Hyland Post on 10 May 1982. Flight notes for that date indicate that it appeared to be a "late spring", i.e., there was still much snow remaining in the study area. One of the collared animals was in the group seen; all but three of the other collared ones had died, and those three were widely separated and in habitats where their group affinities could not be determined. Consideration of observations in May of other years suggests that the above result is anomalous, possibly reflecting the effects of the severe winter, including abnormally heavy snowfall as late as March.

As described previously, the animals move to their consistently lowest annual elevations in May where they may be more difficult to see, especially in forested areas. Group size data for that period are relatively sparse, therefore, but there is some indication (Figure 15) of a slight increase at that time, possibly with animals joining together temporarily as they moved along traditional travel corridors towards distant calving areas.

3.9 POPULATION DYNAMICS

3.9.1 General

Data on natality and mortality have accrued largely incidentally and opportunistically. A helicopter was used to assist in determining maternal status of collared females in mid-June of 1983 and 1984, but that information in 1981 and 1982 and subsequent observations prior to October in all years were obtained only during fixed-wing tracking flights. A helicopter was used for some observations in October of all years, but least satisfactorily in 1983. Mortality investigations were conducted primarily during the June and October periods when the helicopter was available.

3.9.2 ASPECTS OF NATALITY

3.9.2.1 Timing of Calving - No calves were seen during a tracking flight on 30 May 1981, although some collared females may have been at their calving areas at that time. Two small calves were seen and all collared females were believed to have been at their calving locations on 8 June of that year. In following years, the earliest sighting of a calf was on 31 May 1983. Of 10 females observed on that day, two had calves, both less than 2 days old and probably less than 1. An additional 13 females were seen on 1 June and none had calves at that time although at least three were seen with calves by mid-June. The earliest pertinent flight in 1984 was on 5 June, when the only two females seen both had calves. One of those had been born earlier that day, while the other was believed to have been one week or more old.

The latest confirmed calving date was on 15 June 1984, when No. A00 was seen lying beside a newly born, still wet calf. Two collared females seen on 12 and 13 June 1983 and one on 14 June 1984 were considered "possibly still pregnant" although none was seen with a calf on subsequent flights. Of 23 different calves seen from 12-16 June 1984, 17 were large, tan or brown individuals, certainly one week or more old, and the other six were small, reddish ones known or suspected to have been less than one week old.

During the 4 study years, almost all calving was apparently completed within the last week of May to mid-June period, and the peak probably occurred between 3 and 8 June.

3.9.2.2 Calving Success - Table 15 summarizes the maternal histories for collared females during the four study years. All of seven females were known or suspected to have given birth in 1981, but only 68 to 75% were in that category in subsequent years. Among females known or suspected to have been barren in any one year, most were either young or old. No. A04 produced a calf in 1981, but was believed to have been barren in 1982 and was certainly so in 1983 and 1984. No age data were obtained when she was captured because of handling difficulties, but she was later confirmed to be old, probably 15+ in 1984.

Of three other females known to have been barren in 1983, one was old (B12 - 17 years) and two were known (B17) or suspected (C38) to have been yearlings during the 1982 rut. The two animals suspected to have been barren in 1983 were B03 and B24, aged at 2 years and "young adult" (3 years or less) respectively, during the previous rut season.

In 1984, the incidence of known barren females declined slightly, to three, again including A04. The other two, B10 and B11, had both given birth in 1983; their exact ages were not known, but B10 was judged to be about 5 and B11 only 2-3 when they were captured in October 1982. The two suspected barren females in 1984 were young female C38, known barren in 1983, and

Table 15. Calf production and survival observed among radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-1984. N is the number of collared females present. Entries under maternal status distinguish between females for which: a calf was seen at least once between June and October (C); a calf was never seen, but was suspected to have been born (S), known not to have been born (female barren - B), or suspected not born (W), on basis of physical features, location, and/or behavior in early to mid-June; the status in some cases was unknown (U), due to inadequate observations. For summer and fall observations, "C" indicates calves seen during the month indicated. Other designations are for confirmed calf losses (L) since previous observations (females seen without), unknown status (U) because females not seen, or not applicable (N), when females were without calves due to events recorded for previous months.

		Maternal Status										Summer/Fall Observations							
		C		S		B		W		U		July[1]				October[2]			
Year	N	No.	%	No.	%	No.	%	No.	%	No.	%	C	L	U	N	C	L	U	N
1981	7	6	86	1	14	0	0	0	0	0	0	3	0	4	0	2	5	0	0
1982	4	1	25	2	50	0	0	1	25	0	0	1	2	0	1	1	0	0	3
1983	24	14	58	4	17	4	17	2	8	0	0	5	7	5	7	2	4	4	14
1984	22	13	59	2	9	3	14	2	9	2	9	10	2	2	8	9	2	0	11
All	57	34	60	9	16	7	12	5	8	2	4	19	11	11	16	14	11	4	28

[1] Observations from 24 July 1981, 30 June 1982, 28-29 July 1983, and 20-21 July 1984.

[2] Observations from 8-12 Oct. 1981, 27 Sept. 1982, 9-10 Oct. 1983, and 5-8 Oct. 1984.

B14, a large female judged to be 4+ years old in October 1982, but not considered old. She had produced a calf in 1983.

Three of the four females observed over the whole 4-year study period are known or suspected to have had calves in each year, although none raised a calf past July in two consecutive years. Among the 1982 cohort, 6 of 12 females whose June maternal status was determined in both 1983 and 1984 had calves in both years. Only one of those, B20 (10 years old in fall 1982) was known to have raised calves past July in both years, and she may have raised them through fall in both years; she was not observed in fall 1983, but still had at least one calf in November 1984. The 1982 ages of the six females that apparently bore calves in both 1983 and 1984 were 5+, 10, 11, adult (4+) and two young adults (2-3).

Female B20 may have produced twins in 1984. Although only one calf was seen in June, it was in very thick cover where it took a concentrated effort to find and observe even the female. Once she and a calf had been glimpsed, thus confirming maternal status, no further observations were made. She was not seen again until 26 November, when two calves were behaving as though they belonged to her. That such a late observation of two calves might indicate twinning was considered a possibility only because of three other suggestive observations earlier in 1984. On 22 July a female with two calves was observed and photographed from a helicopter on uplands near Buckinghorse Lake. Neither of the calves showed any ambivalence about following and being with that female during the 5 minutes or more that they were observed (Hatler and Hazelwood 1984). On 24 July two females with three calves were found bedded on a snowpatch in the Blueberry Creek area; no other caribou were seen in the vicinity. On 10 October B. Henderson (pers. comm.) saw a group consisting of an adult male, one female and two calves in the Thutade Lake area.

3.9.2.3 Calf Survival - Table 15 lists calf observations in June, July and October of each year, and Table 16 summarizes apparent survival of calves in three periods: early survival, within a week of birth; summer survival, from June through about July; survival to October, when recruitment is usually measured. The July observations represent minimal survival, since only fixed-wing observations were involved, and in many cases calves may have been present without being seen. That is known to be the case for one female in 1984. Taking that bias into consideration, it nevertheless appears that losses were greater before the July period than after.

Differences in sample sizes and in intensity of observations make comparisons involving the first two years difficult. The 1983 and 1984 results are comparable and differ considerably. For calves known or suspected to have been born, survival to October was more than five times better in 1984 than in 1983 ($X^2=7.54$, $df=1$, $p<.01$), and the overall October calf ratio for collared females, including those known or suspected barren, was five times higher in 1984 than in 1983 ($X^2=5.25$, $df=1$, $p<.05$). The differences might have been even greater than indicated, if study circumstances had not affected sample size in each year. In 1984, capture activities in mid-June resulted in abandonment of two large calves whose chances for survival can be judged on the basis that 9 of 11 others at that age survived to at least

Table 16. Summer-Fall caribou calf survival in Spatsizi Wilderness Park, British Columbia, 1980-1984. N is the number of calves known to have been born to collared females. The last column (calf ratio) shows calves per 100 females among the collared sample in October, excluding females with unknown maternal status in 1983 and the two losses referred to in footnote 3.

		Minimum Survival To						Extreme Interpretation[1]			
		Mid-June		July		October					
Year	N	No.	%	No.	%	No.	%	N+	No.	%	Calf Ratio
1981	7	6	86	3	43	2	29	7	2	29	29
1982	3	1	33	1	33	1	33	4	1	25	25
1983	18	13	72	5	28	2	13[2]	18	2	11	9
1984	13[3]	11	85	10	77	9	69	15	9	60	45

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[1] Extreme interpretation: if females suspected barren (Col. "W" in Table 15) actually gave birth and lost calves, the resulting sample size (N+), No. of surviving calves, and worst-case percentage calf survival are as shown.

[2] N = 16 in October, because the maternal status of two females was not determined.

[3] Two females were excluded from the sample because their calf losses, in June, resulted from captured-induced abandonment (see Appendix 1); the actual mid-June calf survival in 1984 was 13/15 = 87%.

October in that year. On the other hand, two females located but not seen in October 1983 had probably lost calves, judging from their locations in comparison to those in other years.

The October calf ratios among the collared females (Table 16) were 2% higher, 11% higher, 15% lower and 18% higher than those among the general survey results for the 4 study years (Table 18). However, because of sample size considerations, those differences are not statistically significant.

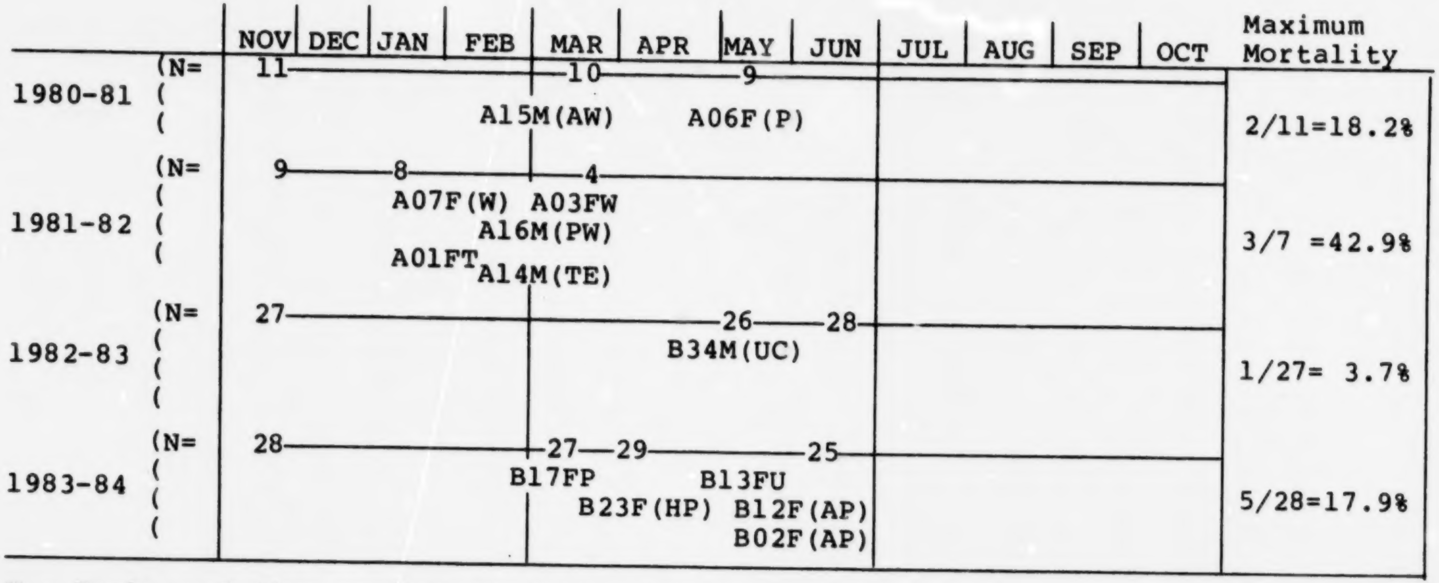
3.9.3 Adult Mortality

A total of 10 collared adults were known and one other suspected to have died from other than capture-related causes during the study period. Appendix 13 details results of investigations at kill sites for those 11 losses. Figure 16 depicts approximate dates and probable causes of all losses recorded, including loss of contact due to transmitter failure or emigration.

Incidence of adult mortality was variable from year to year, with three of seven collared animals dying in 1981-82, and possibly none of 27 dying during the following year. The deaths of almost half the collared sample in 1981-82 all occurred in late winter, and may have been related to the severity of that winter in terms of snow. Among a sample that averaged over 27 animals in the mild winters of 1982-83 and 1983-84, there was only one winter loss and that was to predation.

Although the male sample was small, most losses to that class were in late winter. Among females, there were two late

Figure 16. Incidence and nature of losses among adult radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-1984.



N = Number of live caribou with functioning collars.
Animal identification numbers - A15, A06,...B34; M or F = Male or Female.

Causes of losses: W=winter kill; P=predation; H=poaching; A="old age"; C=loss of collar; T=transmitter failure; E=emigration; U=unknown.

Two causes together, e.g., PW, indicates both possible. Parentheses around cause indicates "probable"; no parentheses indicates known cause.

Denominator under mortality listings is N at beginning of year; T and E not included in numerator.

winter losses in the severe winter, but at least four and probably five of the eight mortalities recorded were in May. Age was apparently a factor in the May losses. Possibly the energetic and/or physical strain of pregnancy was too much for the older females at that time, resulting in illness and death directly, or in increased vulnerability to predation or accidents. As described in Appendix 13, if the deaths of two old females in May 1984 were due to predation, the predators were bears in both cases.

There were no known natural mortalities among the collared animals between June and December. That fact tends to support conclusions (Appendix 1) that losses in late October-November 1980 and 1982 were almost entirely capture-related.

Overall for the 4-year period, there were 8 female mortalities in 62.6 collared female years (0.13 per year) and 2-3 male mortalities in 11 collared male years (0.18 to 0.27 per year). Of the 10 known mortalities, one (10%) was known to have been due to predation, one (10%) was suspected predation, and four others were suspected to have been a result of either predation or some other cause. One male collar could not be retrieved, therefore the death of the animal was not confirmed. Factors such as winter severity and old age probably played a role by increasing vulnerability of at least four of the animals involved.

3.9.4 Population Status, from Census Data

3.9.4.1 Numbers and Trends - Table 17 lists the results of surveys undertaken to provide data on numbers and composition of the Spatsizi area caribou population. The first listed is the

Table 17. Total numbers of caribou and percentages of calves[1] among classified animals counted, by helicopter, in the Spatsizi Wilderness Park area, British Columbia, 1977-1984. In 1977, the survey included most of Tatlatui Park and caribou ranges east of Spatsizi Park; listings under "other" at other times were primarily incidental sightings within Spatsizi Park, but outside the three main survey areas.

	Locations of Counts									
	Caribou Mtn.		Tomias Mtn.		Edozadelly Mtn.		Other		Totals	
Dates	N	Calf(%)	N	Calf(%)	N	Calf(%)	N	Calf(%)	N	Calf(%)
7-9/10/77	348	4.9	1124	4.5	197	14.2	800	11.5	2469	8.2
12-14/10/79	195	9.2	235	9.8	-	-	8	12.5	438	9.6
22/10/79	227	6.6	-	-	-	-	-	-	227	6.6
29-30/09/80	271	13.7	622	11.6	218	14.7	13	0.0	1124	12.5
29/01/81	405	19.8	-	-	-	-	-	-	405	19.8
9-10/10/81	234	9.0	89+	21.4	161	5.0	-	-	484+	7.8
28/02/82[2]	281	16.7	-	-	-	-	77	22.1	358	17.9
4-6/10/82	177	6.2	737	9.0	161	13.0	-	-	1075	9.3
7/11/82	206	14.1	-	-	-	-	-	-	206	14.1
9/10/83	232	15.1	-	-	214	14.0	-	-	446	14.6
6-9\10/84	227	12.8	632	12.6	182	16.5	-	-	1041	13.4

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[1] For consistency with previous major publications referring to caribou population dynamics in the area (Bergerud 1978,1980,1983; Bergerud and Butler 1978), and to enable comparisons between fall composition surveys and other counts, which distinguished calves but did not classify sexes, calf ratios here are expressed as a percentage of the total caribou counted. An evaluation of such ratios is presented elsewhere (Hatler, in prep.).

[2] Surveys began on day shown and were completed on 02/03/82.

highest count ever made in the area, 2469 animals in fall 1977. No count thereafter attained even 50% of that total, probably because no other covered as much area. The 1977 count may serve primarily as an order-of-magnitude indication of the size of the local pool from which subsequent survey samples, and the collared sample, have been drawn. The 4-year dispersion of radio-locations, described earlier, included most of the area covered in the 1977 survey and some others not surveyed at that time.

Most of the fall surveys were conducted on one or more of three upland areas where concentrations of rutting caribou may be found each fall. As shown in Table 17, the highest fall counts on Caribou Mountain and Tomias Mountain were also in the 1977 survey. The 1977 total at Edozadelly Mountain was somewhat less than in two other years, and counts there have remained about the same over the 8-year period indicated, averaging about 190 animals.

At Caribou Mountain, the focal area for this study, the 1977 count of 348 was over 50% higher than the mean high count (228) and 27% higher than the next highest count on comparable dates in following years. Higher counts have been made at Caribou Mountain after the rut, but they were a result of the general northward post-rut movement described earlier and are not directly comparable with the rut survey results.

The largest rut count differences were at Tomias Mountain, where the 1977 count of 1124 was larger than the total for all three areas in all subsequent years. Tomias was the least surveyed of the three areas, but averaged about 660 animals in the three other years of coverage roughly comparable to that in

1977. The highest count after 1977, attained in 1982, was 34% lower than the 1977 total. Overall, no certain trend in numbers is apparent.

3.9.4.2 Population Composition - Table 18 lists some population composition figures as determined from data gathered on the fall rut surveys between 1977 and 1984. The results are pooled over all areas covered on each survey. Area specific calf percentages are given in Table 17. Determination of recruitment, as indicated by calf ratios, was a major objective for all of the surveys listed, and those figures are probably the most comparable. Sex ratios shown are suspect for some years because a high proportion of adults were unclassified.

For the two surveys when all animals observed were classified (1982 and 1983), males constituted 23-24% of the total sample and 26-28% of adults. Fewer than 10% of those were small males, i.e., 1-2 year olds. The female component, 72-74% of adults in the rut area samples, included yearlings.

The highest calf ratios, 13-15% of total samples, were found in 1980, 1983 and 1984. As shown in Table 17, the highest ratios within years were usually found on the southernmost rut area, Edozadelly, and the lowest was often at Tomias, the area with the most animals. As was also shown in Table 17, counts at Caribou Mountain a month or more after the 1980, 1981 and 1982 rut surveys all found considerably higher calf ratios than had been tallied on the rut counts. Assuming equal representation by bulls in the later counts, those differences could be the result of the differential movement and distribution patterns of females with and without calves (3.5.2, 3.6.2).

Table 18. Number of animals classified to at least adult/young separation and fall population composition of caribou in the Spatsizi Wilderness Park area, British Columbia, 1977-1984. Large bulls are those recognizable by antler characteristics alone, i.e., large plus medium bulls in most classification lists, and therefore mostly at least three years old; small bulls are those distinguished by observation of genitalia. Cows are females at least one year old, distinguished by presence of calves and/or by genitalia, while unclassified adults are animals one year old or older, but sex not determined. Under bulls/100 females, two figures are shown: X/Y where X is based only on large bulls and Y is based on the minimum total (all sizes) present.

		Adult Sex Ratios						Calf Ratios		
		Bulls								
		Large	Small	Total	Cows	Unclass. Adults	Bulls/ 100	Calves	C/100	C/100
Year	N	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)	Females	No. (%)	Adults	Females
1977	1270	192(15)	10(1)	202(16)	207(16)	724(57)	-[1]	181(8)	9	-[1]
1979	438	- -	- -	80(18)	202(46)	110(25)	-/40	42(10)	11	21
1980	1124	101(9)	4(-)	105(9)	25(2)	853(76)	-[1]	141(13)	14	[illegible]
1981	409	50(12)	22(5)	72(18)	118(29)	187(46)	42/61	32(8)	8	27
1982	1075	163(15)	89(8)	252(23)	723(67)	0(0)	23/35	100(9)	10	14
1983	446	82(18)	25(6)	107(24)	274(61)	0(0)	30/39	65(15)	17	24
1984	1041	171(16)	62(6)	233(22)	429(41)	240(33)	25/39[2]	139(13)	15	27[2]

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[1] In 1977, N for sex ratios is that shown while that for calf percentage is 2205; too few females were classified for calculations based on 100 females both then and in 1980.

[2] Not including data for groups with unclassified adults.

3.9.5 Population Status, from Collared Sample

Based on observations of both reproductive performance and mortality among collared animals from 1980-1984, as described in preceding sections, there may have been substantial winter losses in 1981-82 (Figure 16) although that result is not apparent in a comparison of the census results in Table 17. Relatively good average survival in the following years (maximum of 6 losses in 55 animal years) coupled with apparently good average recruitment in those years, suggests that the population is increasing at this time. That result is not apparent in Table 17 either.

4. DISCUSSION

4.1 WEATHER

Weather affects both behavior and population dynamics. The three factors that seem to be most significant are winter snow, spring melt patterns, and precipitation at calving, with temperature playing a modifying role.

Total winter snowfall is important, as is its pattern of accumulation. Large dumps of snow over short periods may have more significant effects on caribou mobility and foraging opportunity than frequent lighter snowfalls, and heavy snows early in the winter may have more impact than those later. The patterns for the four study years in relation to 25-year normals were as follows:

1980-81 (severe) - 24% higher than normal total snowfall, due primarily to a 330% greater than normal fall in December; that during the rest of the winter was at or below normal.

1981-82 (very severe) - 71% higher than normal total snowfall, due to 473% and 296% greater than normal deposits in January and March, respectively.

1982-83 (mild) - 21% lower than normal overall, with much less than normal snowfall in December and March, and approximately normal deposits in January and February.

1983-84 (mild) - 26% lower than normal for the winter, despite a 2X over normal snowfall in January; that in all other months less than normal.

Spring melt patterns vary from year to year, affected both by the extent of the winter snowpack and by temperatures in April and May. The most important effect is the resulting variation in the extent of snowfree areas and spring phenology in upland calving habitats. Conditions during the study years were as follows:

1981 - lowlands open, but snow cover of 50% or more in areas above 1500 m as late as 26 June.

1982 - snow cover above 1500 m still nearly continuous on 7 June.

1983 - snow line at about 1500 m on 31 May, with only patches in uplands; Fire Flats almost completely snowfree.

1984 - snow cover above 1500 m still mostly continuous; Fire Flats still mostly snowbound on 4 June.

Comparatively, 1981 was either about normal or somewhat slower than normal in the advancement of spring, while 1982 was certainly characterized by a retarded spring, owing both to the record accumulation of snow the previous winter and to continued cold temperatures, with snowfall, into May. By far the earliest spring was in 1983, with little snow remaining anywhere by mid-June. In contrast, despite a relatively small accumulation of snow during the 1983-84 winter, cold temperatures in May 1984 resulted in a greatly retarded spring, at least as late as that in 1982, with abundant snow cover remaining in study area uplands during the peak calving period.

Precipitation during the calving period is important because caribou are born wet, and must get dry before the insulative value of their pelage is realized (see Lentz and Hart 1960). During the first 10 days of June, when most calves are born, the total precipitation in the four study years was 26, 1, 51 and 14 mm, respectively. Further, the mean annual precipitation during that 10-day period was greater for the half-decades of 1975-1979 and 1980-84 than in the preceding 25 years (Fig. 3). Thus, the Spatsizi studies began during a series of the wettest early-June periods recorded for the area, and that period in 1983 was by far the wettest during the present study.

4.2 PHYSICAL CHARACTERISTICS

4.2.1 Age

Few studies have documented the ages of woodland caribou, and there have been none prior to this one in British Columbia. Of special interest in the Spatsizi sample is the high proportion of older females, with 10 of 20 (50%) in the 10+ category. By contrast, in a Newfoundland sample only 6 of 89 females of known age (7%) were as old as 10 (Bergerud 1971). In northeastern Alberta, 4 of 10 (40%) were in that category among females captured (Fuller and Keith 1981). In large and assumed unbiased samples of barren ground caribou, females of age 10+ have constituted just 22 of 302 (7%, Kaminuriak Herd, Miller 1974) and 1 of 85 (1%, Porcupine Herd, Martell and Russell 1983).

If our collared sample accurately represents the Spatsizi population, the preponderance of old females might reflect unusually good cohort survival in the early 1970's and/or relatively poor survival of cohorts from the mid- to late years of that decade. That interpretation would support the decline scenario postulated by Bergerud (1978). However, the observed age distribution of the collared animals may be biased. If so, the most likely bias relates to the timing and location of the main capture programs, i.e., on Caribou Mountain shortly after the rut. Unsuccessful mothers are more likely to be present at that time and place than are successful ones. Since a high proportion of the unsuccessful mothers are old (3.9.2.2), more older females than representative could have been captured. Also, the actual captures may have been selectively biased.

Females with calves were more wary than those without, and were more difficult to drive, approach, and hide from. Since only 8 of 39 female captures (21%) involved mother-calf pairs, possibly the captures inadvertently focussed on less productive, less wary individuals, of which many might have been old.

There are management and research implications whether the data are accurate or biased. If the age data were the result of the first bias described, that would constitute further support to my suggestion that the routine fall rut counts do not produce representative data on population composition (Hatler 1983, 1985b). Overall, it seems important to know at least the relative ages of adult females being observed, because not all are equal contributors to population productivity. Further, their individual movements, ranges, and behavior in a given year vary with reproductive success.

Males in the Spatsizi sample averaged 5 years old, or 3 years younger than the females (summarized from Appendix 3 and Hatler 1983). The average age of males was also lower than that of females in other areas, but the disparity was not as great as at Spatsizi (3.0 vs. 4.7 in Newfoundland, Bergerud 1971; 6.1 vs. 6.9 in Alberta, Fuller and Keith 1981; 3.4 vs. 3.9 in the Porcupine herd, Martell and Russell, 1983; 3.8 vs. 5.0 in the Kaminuriak herd, Miller 1974). In comparison to the Spatsizi sample, where 2 of 13 males were 9 years or older, there were none that old in the Newfoundland sample (N=42), 2 of 23 were 10 years or older in Alberta, none of 108 were older than 9 years in the Porcupine herd, and there were just 2 of 340 males in that category in the Kaminuriak herd (one 11 and one 12 years old).

Those data generally reflect the higher mortality rates and lower life expectancy for adult males (Bergerud 1980), perhaps largely as a result of injuries and energy drain during the rut.

The Spatsizi male ages were probably not representative of the population. The mature males were relatively easy to recognize and capture, but because collar retention is better on smaller-necked young males, and because the chances for tracking over the full life of the transmitter batteries seemed better for that class, young animals were selected to constitute at least half of the male sample. Thus, the average age of captured males is probably less than the population mean. Nevertheless, the Spatsizi males were older than those in all of the other studies cited except Alberta, and the Spatsizi females were much older than in the other studies.

More age data are needed for the general Spatsizi population, but the apparent relative longevity there, as indicated by the collared sample, is not consistent with the scenario of widespread, intensive wolf predation on all age classes postulated for northern B.C. in the 1970's and early 1980's (Bergerud 1980, 1983).

4.2.2 Body Size

Measurements of 30 animals from the 1982 cohort confirm the previous conclusion (Hatler 1983), that Spatsizi caribou are among the largest caribou known, but that they are apparently no larger than some other woodland caribou, e.g., those in northeastern Alberta (Fuller and Keith 1980). Females measured in west central Alberta (Edmonds and Bloomfield 1984) averaged larger in total length, and were slightly larger in heart girth, but those measurements were of animals that had not been anesthetized, and it was acknowledged that some may have moved or struggled during the measurement process. Gauthier and Farnell (1985) compared measurements of animals from several Yukon caribou herds with those from the 1980 Spatsizi cohort (Hatler 1983) and the western Alberta animals of the Edmonds and Bloomfield (1984) study. They found that the two most southerly groups were generally larger than woodland caribou in the Yukon, and all woodland types were larger than representatives from the Porcupine herd of barren ground caribou, thus supporting Banfield's (1961) hypothesis of a north to south gradient of increased body size in the species.

4.2.3 Antler Characteristics

The antler development of Spatsizi caribou bulls, peaking at about ages 5-7 and regressing thereafter (3.2.3) is similar to that described for Newfoundland animals (Bergerud 1976). However, the antlers of Spatsizi females apparently increase in size to at least 9 years, as compared to 3 or 4 in Newfoundland; the largest observed were on a large-bodied 12-year old. Antler regression among females began after age 12.

Since most of the Spatsizi females have antlers (94% of 36 in the collared samples; 99% of 294 in a sample observed by Bergerud and Butler 1978), the possibilities for enhancing understanding of population composition and status by reference to antler characteristics should be more closely examined. Bergerud (1976, 1978) has used antler characteristics to help interpret the maternal status of females in spring and the timing of estrus in the fall, and to assess the age structure of males.

Possibly observations during the post-rut/early winter period could provide additional data on male ages, since older males drop antlers earlier than do young ones. Finally, observations of the collared animals indicate that many of the potentially least productive females, the young and the old, may also be recognizable in fall and winter groups. If that is true, current caribou hunting seasons could possibly be altered to take some pressure off older males and redirect it to immature males and unproductive females, as defined by a combination of absence-of-calf and antler characteristics.

4.3 HOME RANGE

The minimum time period of reference for home range calculations in the Spatsizi studies has been one annual cycle. Most of the total individual ranges reported were based on from 2 to 4 years of observations. Although seasonal ranges were identified, the extent of movements within and relative sizes of each were not described, because of the relatively few observations pertaining. The predominant feature of annual range sizes recorded for the collared caribou was variability, both between individuals and between years. The primary factors in individual range size were the distance between winter and summer ranges, and the degree of fidelity to the summer range. The individual differences in seasonal movements and home ranges were the first clue that there are at least two and probably three herds in the Spatsizi population; those herds are essentially separate reproductively in that they produce calves and rut in different areas, although all may be found in the same winter area in the Stikine River Valley (4.4, Hatler 1985a).

Different authors have calculated or expressed range sizes in different ways, so comparisons are difficult. The mean annual range sizes calculated for up to 20 males and up to 7 females in northeastern Alberta were 1196 km² (range 745-1807) and 539 km² (261-810), respectively (Fuller and Keith 1981). As described earlier, annual ranges for the Spatsizi animals were so variable that mean values did not seem instructive but they are given here for comparative purposes. Considering only annual ranges based on 10 or more locations, those for males varied from 737 to 2828 km² (mean 1371, N=6) and those for females were 170 to 9941 km² (mean 1526, N=38). Members of the more sedentary northern group had annual ranges that approximated those in Fuller and Keith's (1981) study area, while the ranges of those that move south from the winter range were larger.

Individual caribou ranges in some other areas have been smaller than those recorded in northeastern Alberta. In the Columbia Mountains of southeastern British Columbia, the mean annual ranges for three females and two males monitored for 1-3 years each was 460 km² and 177 km², respectively (Simpson _et al_. 1984). In a west central Manitoba study, the total "aggregate range" of 11 collared caribou monitored over a 3-year period (Shoesmith and Storey 1977) was just 1780 km², an area only slightly larger than the mean annual ranges given above for Spatsizi females, and smaller than the individual annual ranges for many of them. The reasons for the more sedentary nature of the Alberta, southern British Columbia and Manitoba herds cannot be determined with information available, but one possibility is some kind of selection against more mobile groups that may have formerly occurred in those areas. Given a population with both mobile and sedentary traditions, the former would probably be most vulnerable to encroaching civilization, especially where linear developments such as transportation corridors and reservoirs are involved (Stevenson and Hatler 1985, Hatler 1985a).

A distinct feature of the comparison between the Alberta and Spatsizi results is the difference in range sizes between the sexes. Males in Alberta had mean annual ranges more than twice as large as females, while in Spatsizi female ranges generally exceeded those of males. The reasons for and significance of that difference are not known, but they may merely be artifacts of sample size. There were relatively few females in the Alberta sample, and relatively few males at Spatsizi.

An important finding in the Spatsizi studies is that observations over more than one annual cycle are required to fully describe an animal's use of the area. Since individuals used different seasonal ranges or the same seasonal ranges in different ways in different years, the total home ranges for most increased from year to year. Those results demonstrate the inadequacy of short-term studies to predict local developmental impacts. An overall conclusion is that, because of the cumulative effect of individual dispersal and range use strategies, a large area is needed to support a large, relatively pristine population such as that at Spatsizi.

4.4 MOVEMENTS

The annual pattern of movements documented for the Spatsizi caribou, with the largest, most directed travel in spring, more leisurely wandering locally or generally back toward fall and winter areas in summer, minor peaks of movement before and after rut, and again mostly local wandering in winter (Section 3.4.2), appears to be fairly general for the species. That includes barren ground caribou (Kelsall 1968, northern Canada; Hemming 1971, Alaska), some wild reindeer in Europe (Pulliainen et al. 1983), and other woodland caribou (Bergerud 1974, Newfoundland; Edmonds and Bloomfield 1984, Alberta). The primary area-to-area differences are in the scale of movements, as reflected in the distance between winter and summer ranges, and in timing.

The most anomalous long distance movement in the Spatsizi studies occurred in December 1980, in response to an unusually heavy snowfall at that time (Hatler 1983). That movement took collared animals to alpine areas both west and north of the main wintering area that has been used in subsequent years. Long distance movements in response to increased snow cover was also recorded by Edmonds and Bloomfield (1984). For the Spatsizi animals, ranges to which many had so laboriously moved appeared little different from those they had left. Nevertheless, movement in response to heavy snow accumulation is probably a good strategy, maximizing the animals' chances to locate areas where local microclimatic effects have ameliorated snow conditions, or possibly even enabling them to escape effects of a locally restricted storm.

Probably the most important finding in the Spatsizi work has been the difference in extent and timing of summer and fall movements between females with calves and those without. Females with calves were far more sedentary through October than were both barren females and females which had lost calves. Therefore, counts designed to assess recruitment must take into consideration the resulting differential distribution of mothers and other females. Fall rut counts in restricted aggregation areas in northern British Columbia may miss significant proportions of the maternal groups.

4.5 DISTRIBUTION AND RANGE

4.5.1 Dispersion

The pattern documented for the Spatsizi collared animals included extreme dispersion in June, decreasing thereafter to extreme concentration in early winter, and then increasing slightly but remaining relatively concentrated throughout the winter (Figure 8). The same pattern seems to occur in at least the most strongly migratory herd studied by Edmonds and Bloomfield (1984). The tendency for animals to be most solitary in summer in that study and others (Shoesmith and Storey 1977, Fuller and Keith 1981, Farnell and Russell 1984) suggests that a high degree of summer dispersion may be general for woodland caribou. The latter two sets of authors as well as Bergerud *et al.* (1984b) have all speculated that such dispersion is an antipredator strategy to protect the young.

4.5.2 Seasonal Distribution

Winter distribution varies both between and within years, apparently depending on snow cover characteristics. During two low-snowfall winters, when mobility was relatively unimpeded, most caribou occupied the extensive pine-dominated forests on both slopes of the Stikine River Valley, paralleling the north boundary of Spatsizi Park. After a heavy snowfall in December 1980, they were more widely dispersed in open, windblown alpine habitats, especially to the west and north. During the winter of heaviest snow accumulation, 1981-82, most used lowland habitats near Coldfish Lake although some moved into nearby alpine areas in March. At least two made extensive movements and four moved very little. The lack of a uniform strategy for dealing with that winter suggests that the animals were under some stress, and were not finding ideal conditions anywhere. A similar result in 1981-82 was reported for caribou in western Alberta (Edmonds and Bloomfield 1984). In the northcentral Yukon, Farnell and Russell (1984) flew only in March, but they noted a generally more restricted distribution and use of habitat at that time in 1982 than had been the case in the previous year.

During the spring dispersal, the collared Spatsizi caribou went in many directions and some to great distances (3.6.3). Most spring movements and summer locations of females were to the south, mostly to uplands within the drainage of the Upper Stikine River, although some occupied mountains in the drainages of the Skeena, Finlay and Nass Rivers as well. There is a gradient of increased winter snow to the south and west in the study area (Hatler 1983), so that those movements were to areas that are wetter and probably provide lusher vegetation in summer than do the dryer microclimates in the northern portions of Spatsizi Park.

The relative absence of caribou in early summer in the immediate vicinity of the three upland plateaus that constitute the rut survey areas is interesting. The animals appear in those areas by July, beginning primarily with bulls and females without calves, and numbers build from there throughout the summer. Aggregations have always been found in those areas during the rut (3.6.4), but not all collared caribou have attended them. The most frequent absentees, proportional to their occurrence, have been cows with calves. The concentrations of caribou in those areas, together with the potential for injuries and deaths of males due to fighting (Bergerud 1980), seems to attract predators, and there have been regular observations of wolves and occasional sightings of grizzly bears and wolverines during the rut surveys over the years (unpubl. data, personal and provincial government files). The relative absence of females with calves in those areas may therefore be a biological strategy.

4.5.3 Migration

Kelsall (1968) distinguished barren ground caribou as "truly migratory" on the basis of their making "...directionally oriented, purposeful, and uninterrupted movements twice annually between distant winter and summer ranges". He further observed that, "No other North American caribou have developed so strong a migration pattern, and many must be considered nomadic only, or even sedentary". Those statements remain generally accurate, although recent radio-tracking studies of woodland caribou have demonstrated definite migratory patterns in at least some groups of that subspecies as well. The difference is largely one of scale (see 4.2.4). The maximum spring movements recorded for individual woodland caribou (150 km, female, Edmonds and Bloomfield 1984; 125 km, female, this study) approached the lower limit of migration distance (160-1120 km) listed by Kelsall (1968) for the barren ground animals.

As described by Simpson et al. (1984), seasonal movements in their southeastern British Columbia study areas were mainly local, up and down slope. Movements of radio-collared animals in a Manitoba study area were not quantitatively summarized by Shoesmith and Storey (1977), but text accounts indicate that some individuals may have spent winters and summers in essentially the same area, apparently moving only a few kilometers, while at least one female was recorded as moving 38 km to a winter area. For the northeastern Alberta animals studied by Fuller and Keith (1981), distances moved between winter and summer ranges appeared to be on the order of 30-40 km for males and about 20 km for females, while in west central Alberta, Edmonds and Bloomfield (1984) documented two patterns of migratory movements by their collared animals. Those two patterns were attributed to two different "populations" that wintered in the general vicinity of Grand Cache. One, which they called "mountain caribou",consisted of mobile individuals that moved an average of 84 km to alpine summer ranges in the west, and the other was a more sedentary group that remained in the forested foothills throughout the year ("woodland caribou", mean distance between winter and summer ranges = 31 km).

The Spatsizi results show a pattern similar to that in western Alberta, with a relatively sedentary group remaining, in summer, in the north, mostly within 30-40 km of the lower Stikine wintering area, and a more mobile group that moves 50-75 km south to the Ross-Stikine headwaters area. There also appears to be a third group, which spends the summer in the Tatlatui-Lawyers Pass area and includes individuals that travel 100 km or more to get there. The collared sample has also included other long distance movers, outliers whose group affinities, if any, are not yet apparent.

An important aspect of the Spatsizi findings is that the tendency to migrate or not and the direction/distance of movements are individual, not population traits. From the same wintering population, the spring dispersal has resulted from individual migrations in all directions and to varying distances, and those migrations are apparently traditional at the individual level (3.6.5 and 4.2.6). In the far north, where the distribution of forested winter habitat and summer tundra habitat is a latitudinal phenomenon, strongly directional (usually north and south) movements must be the rule. In mountainous areas, where the effects of elevation replace those of latitude, migration does not necessarily have to be directional; the alpine-tending caribou in western Alberta moved generally southwest from their forest winter range (Edmonds and Bloomfield 1984) because that is where the mountains are.

Some degree of migration presumably confers the same benefits to woodland caribou as it does to the barren ground animals: a) allowing them to exploit certain habitats when they are productive and to avoid them when they are not, and b) allowing them to disperse to areas where predators cannot become entrenched. Populations with at least some migratory tendency therefore must have a better potential for growing and maintaining numbers than do those without.

4.6 FIDELITY TO SEASONAL RANGES

Shoesmith and Storey (1977) reported that one of their collared female caribou calved on the same small island in three consecutive years, while the other calved on one island twice consecutively, but was on other nearby islands in two other years. Edmonds and Bloomfield (1984) had relatively few observations during the calving period, but noted that cows did return to the same general areas each summer, and that one was found "on the same slope in the same basin" during calving surveys in three consecutive years. In the Yukon in 1982, Farnell and Russell (1984) found 6 of 10 live females "in almost exactly the same areas" as in the previous year. Only two were in greatly different areas, possibly because they were not calving; their maternal status was not determined. Homing to at least the same general area in spring was a conspicuous feature of the Spatsizi radio-tracking results. It was true primarily for parous females, although a moderate homing tendency was also documented for some barren females and for males. The degree of homing in some cases was phenomenal. Starting from the general vicinity of the Spatsizi River mouth in early May of both 1981 and 1984, No. B20 moved approximately 100 km south and was found with newborn calves in the same gully on the north side of Groundhog Mountain in early June of both years. Clearly there is considerable fidelity to calving areas, and homing to those areas in spring is the general rule. It is the cases in which homing does not occur that need to be explained.

The question of individual fidelity to other seasonal ranges will be examined in a future report. The general impression in the Spatsizi studies, as well as in Edmonds and Bloomfield (1984) and Farnell and Russell (1984), was that the animals are less tied to any specific places in other seasons, and that is particularly true in winter.

4.7 HABITAT CONSIDERATIONS

4.7.1 General

To date most observations relating to caribou habitat in the Spatsizi studies have simply involved describing the locations of collared caribou with reference to elevation, slope direction and broad vegetative cover during the various radio-tracking flights. However, all locations have been carefully mapped, so there is some potential for more intensive habitat-use analyses, in conjunction with detailed vegetation mapping, in the future. For most of the findings reported here (3.7.2-3.7.3), there are few comparable published results. Other studies have described features of habitats used by radio-collared woodland caribou, but most have been in areas where there was no potential for altitudinal movements between forest and tundra (e.g., Shoesmith and Storey 1977, Fuller and Keith 1981, Darby and Pruitt 1984). Among studies in mountainous terrain, that of Oosenbrug and Theberge (1980) provided detailed analyses of habitats and slopes used by caribou in the Burwash Uplands, Yukon Territory, but their observations were limited to summer-early fall, and did not involve radio telemetry. They acknowledged that their relative inability to see animals in forest and tall shrub habitats resulted in at least some bias in their results. Bloomfield

(1980), studying caribou in the mountains of central British Columbia, also worked without the benefit of telemetry. Farnell and Russell (1984) were following radio-collared animals, but they described most seasonal habitats in only general terms. The most complete seasonal habitat descriptions for a mountain study area are those of Edmonds and Bloomfield (1984), but they are not strictly comparable with the Spatsizi findings either, since they included the combined results from several study activities including intensive ground and aerial observations of uncollared animals, especially during winter.

The general pattern of annual habitat use documented for the Spatsizi animals, with most animals in high elevation, subalpine and tundra habitats in summer and fall, and most in lower forested habitats in winter, has also been the case for other mountain dwelling populations, as described or implied in the sources cited above. The Spatsizi caribou have consistently occupied the lowest elevations of the year during the early spring period, before and during the migration of females to calving areas (Fig. 12). That result was also reported for caribou in southern British Columbia (Simpson et al. 1984) and is suggested in data presented by Bloomfield (1980). The longer use of the spring lowland habitats by some classes of animals, especially bulls, was assumed to be the case by Oosenbrug and Theberge (1980), based on the relative absence of those animals during observations in open, upland habitats at that time. A similar result is implied by Edmonds and Bloomfield (1984), who observed that bulls began spring movements later than did cows. The Spatsizi data confirm that spring pattern and indicate that barren females may at least occasionally behave like bulls, migrating later and staying lower than parous females in that season. More detailed discussions of habitats used during calving and winter are presented in following sections.

The data on direction-of-slope occupied by caribou during this study (3.7.2.2) were not analyzed in relation to known slope availability. Thus, if some kinds of terrain such as cliffs or long ridges are more common in particular directions in the study area, the data are biased. My subjective impression, based on hundreds of hours' flying in the area, is that such biases, if present, are small.

The year round preference for north and south slopes documented for the Spatsizi caribou was apparently not the case in other studies that recorded such data. Bloomfield (1980) also found an overall greater use of north-facing slopes, but west-facing slopes were used somewhat more often than were south aspects, and the range of percentage occurrence values for the four slope directions (30-46) was less in his central British Columbia study area than was the case in Spatsizi (17-52). In west central Alberta, caribou were found on south facing slopes most often, especially in winter, and north ranked third in both winter and summer observations (Edmonds and Bloomfield 1984). Differences between areas likely reflect local differences in microclimatic effects on such factors as snow cover, snow melt patterns, drainage, and possibly insect occurrence. Wind patterns may be particularly important.

4.7.2 Winter Habitat

Kelsall (1968) indicated that most barren ground caribou usually winter in the forest, but that there are always some and occasionally many on the tundra in that season. He described one instance in which 48,000 caribou wintered in a tundra area of little snow cover, apparently after first penetrating the forest, encountering heavy snow conditions there, and turning back north. The collared Spatsizi caribou were all below treeline during two winters when there was insufficient snow to hinder their movements, and some or all were on alpine tundra for all or parts of two winters with adverse snow conditions (3.7.2-3.7.3). The unusually heavy early December snowfall in 1980 apparently established the pattern of caribou distribution for the rest of that year, when virtually all of the collared animals and many uncollared ones throughout the general study area remained above timberline. That December snowfall may have been a fairly local phenomenon, restricted to portions of northern British Columbia, because other studies in progress at the time did not report it.

In contrast, the winter characterized as having the severest conditions in this study (1981-82), was documented as the worst of three winters on a west central Alberta study area (Edmonds and Bloomfield 1984), and was also described as a winter of deep snow in northcentral Yukon (Farnell and Russell 1984). During that winter, the Spatsizi caribou showed a variable response, with some occupying alpine and some in lowland habitats, and with a significant movement onto alpine ranges in early March (3.6.2). Meanwhile, in Alberta, the animals were able to crater through the deep, though relatively soft snow in the forest during most of the winter, although some made sudden long distance movements in February and many moved into alpine areas in April (Edmonds and Bloomfield 1984). The most conspicuous occurrence during the 1981-82 winter in the Werneke Mountains, Yukon, was an influx of barren ground caribou (Porcupine Herd) that partially overlapped the winter ranges of two local woodland caribou herds (Farnell and Russell 1984).

It seems evident that snow conditions have played the primary role in determining winter habitats used. Since there was little snow and little hindrance to mobility in the two mild winters (1982-83 and 1983-84), it appears that the Spatsizi animals' forest occurrences in those years reflects some kind of choice, while alpine occurrences in parts or all of the other years was a matter of necessity. That is, the appearance of animals in alpine areas in winter may indicate some kind of stress situation in the use of preferred habitats.

The primary winter habitat for Spatsizi caribou below timberline has been mature forest in which pine is present and is usually dominant, although some animals have made extensive use of thick, stunted subalpine fir patches, especially in early winter. Open areas below timberline, including muskegs and shrub or herb meadows, were also widely used, especially in the two low-snowfall winters. The detailed descriptions in Edmonds and Bloomfield (1984) indicate that their study caribou used very similar habitats in western Alberta, and under similar circumstances.

4.7.3 Calving Habitat

Surveys that rely solely on visual contacts with the animals tend to produce results which are biased to open habitats. As shown by the radio-collared females of this study (3.7.4), calving habitat is much more variable than previous studies have indicated (see Bergerud *et al.* 1984b). Although south-facing slopes are generally more phenologically advanced and are favored by females that move the highest for calving, fewer than 50% of 43 occurrences among parous collared females were on south-facing slopes, and fewer than 50% were above the subalpine zone. About a quarter of the calving sites were on north-facing slopes, and 37% were below timberline. Farnell and Russell (1984) documented some calving below timberline in the northern Yukon, while farther south in the Territory, Oosenbrug and Theberge (1980) found none above that level. Caribou have also been found calving in the forest in the mountains of central (Marshall 1984, pers. comm.) and southern British Columbia (Simpson *et al.* 1984).

The main thesis of Bergerud *et al.* (1984b) is that the spring dispersal of females for calving is primarily to enable them to avoid predators. Limitation of the animals to one or few local habitats, e.g., "high south slopes", would seem to be counterproductive to such a strategy. The telemetry data indicate that the dispersal develops in the full sense of the word, with many different habitats, including those under concealing vegetative cover, being used.

4.8 SEASONAL AGGREGATION

The seasonal pattern of changes in group size now seems fairly well established for woodland caribou. Even given major differences in habitats and populations between areas, the basic theme of smallest groups in late spring-early summer, increasing group sizes in fall, and then somewhat smaller groups in winter, appears to be the rule (Shoesmith and Storey 1977, Fuller and Keith 1981, Darby and Pruitt 1984, Edmonds and Bloomfield 1984, this study - Section 3.8). Following paragraphs discuss the major features and implications of aggregation behavior in selected seasons.

4.8.1 Spring

The spring dispersal of individuals in many directions from the winter area results in the annual low in aggregation. Because pregnant females are the first to leave, a degree of sex aggregation also results (Fuller and Keith 1981, Helle 1980, Heikura *et al.* 1983, Edmonds and Bloomfield 1984).

4.8.2 Summer

After calving, parous female barren ground caribou join together, and occasionally with other classes of animals, into large post-calving aggregations (Kelsall 1968, Bergerud 1974). Because that grouping is such a conspicuous and significant event in the annual cycle of the barren ground animals, it is important to consider whether it also occurs in woodland caribou. Farnell and Russell (1984) reported group sizes ranging from 2-131 in July 1980 (northern Yukon), Oosenbrug and Theberge (1980) reported "post-calving aggregations" of up to 150 animals in the Burwash Uplands, and Bergerud *et. al.* (1984b) found a peak aggregation of 236 animals on Fire Flats, Spatsizi Park area, at the end of June in 1977. Therefore, it is evident that some fairly large groups do occur among woodland caribou at that time, although they may differ in composition from those seen on the barren grounds.

The use of telemetry has improved our understanding of the growth and composition of those aggregations in the Spatsizi area. Previously, Bergerud et al. (1984b) interpreted the gathering group of caribou on Fire Flats in June and early July as a post-calving aggregation in the barren ground sense, and apparently expected most local females to eventually join it. They found the initial assembly to be composed largely of bulls, yearlings and non-parous females, and documented an increasing number of parous females after calving, mostly those that had lost calves. However, they also asserted that "...even those females with calves still alive moved to the lowlands...during the last week of June and first week of July".

The telemetry data have not confirmed a downslope movement for successful mothers. Among females observed both in early June and later in the month, the predominant elevational tendency was upslope from the birth site, and the largest downslope movement (300 m) was by a female which had lost her calf (3.7.4). Repeated observations of the collared animals indicate that there are several kinds of aggregations after calving, including a) small maternal bands usually found at high elevation and consisting of 1-6 cow/calf pairs and often a few other females including unsuccessful mothers (calves lost) or yearlings, b) small bands of unsuccessful mothers and yearling females, c) small bands of males, non-parous females and yearlings of both sexes, and d) large bands (20+), consisting of combinations of all three of the foregoing, but always with relatively few successful mothers. The differential composition and distribution of those different kinds of groups is important in the context of population inventory.

Observations of the collared animals and reinterpretation of data presented by Bergerud _et al._ (1984b) indicate that the "post-calving aggregation" at Fire Flats is composed mostly of males and females without calves, and that most maternal groups remain at higher elevations. Thus, their 1976 and 1977 estimates of calf mortality based on counts at Fire Flats were negatively biased.

The circumstances of the relatively few females observed with calves on the Flats in 1977 (Bergerud _et al._ 1984b) are not known. As suggested by those authors, they may have descended from more secure upland calving areas. If so, that appears to be a departure from the general pattern, possibly because those females were young and inexperienced, or because they had inherited or learned a largely inappropriate movement pattern. They may also have calved on or very near the Flats, as part of the general expression of dispersal throughout the entire area. Whatever, they should not be considered as a significant representation of successful mothers in the area. Viewed in the context of an antipredator strategy of dispersal, a large post-calving aggregation of females with calves does not make sense, and the evidence from this study is that it does not happen to any significant degree. Nevertheless, as noted by Bergerud and

Butler (1978), the summer assemblage of caribou at Fire Flats may be the largest its kind in British Columbia, particularly in a lowland habitat, and it would be interesting to know what attracts and holds the animals there, and why local numbers vary from year to year.

4.8.3 Fall

Most of the studies cited previously have documented larger mean group sizes in fall, as the animals gather for the rut. Nevertheless, not all animals are in large groups at that time. The majority of groups recorded even in that season were in the 1-5 animals category. During a survey on the three Spatsizi rutting areas in 1984, 40 of 66 groups observed (61%) were in groups of 10 or fewer animals (Jones 1984).

Fairly early during the routine fall surveys that began in the mid-1970's, some observers noted that large groups appeared to have lower calf ratios than smaller groups. To assess that possibility, Ramey (1984) analyzed all survey data from 1976-1983 and concluded that a) "the proportion of calves decreases exponentially as the group size increases", and that b) "small groups contribute relatively more calves to the total count than do large groups".

The large, post calving groups, consisting of bulls, yearlings, non-parous females and unsuccessful mothers, may stay more or less together throughout the summer, and form the nuclei for the large groups counted in the fall. The small autumn groups are often formed from the local maternal groups described previously, and that is why their calf component is larger. It is important to point out, however, that Ramey's (1984) analysis was based on groups actually occupying rutting areas; findings in this study indicate that many maternal groups do not even appear in those areas during the rut (3.6.4.3).

Similar results were obtained for a lowland Alberta population (Fuller and Keith 1981). They wrote that "Through the rut, cows with calves associated predominantly with single adult bulls; cows without calves were with both adult and young bulls and other cows". As at Spatsizi (3.5.4 and 3.6.4.2), the outlying cows with calves joined the other caribou groups primarily in November.

4.8.4 Winter

Both between and within areas, the most variable aggregation tendency was in winter. During the mild winters in the Spatsizi area (3.8) and generally in other mountainous study areas with relatively large populations (Edmonds and Bloomfield 1984, Farnell and Russell 1984), the animals were relatively dispersed in small groups. That was particularly true while they were in the forest. However, when they moved up to alpine habitat in winter, apparently in response to adverse snow conditions in the forest, group size tended to increase and some of the largest groups observed in the Spatsizi area were under such circumstances.

It seems evident that the winter appearance of large groups of caribou at or above timberline indicates an obligatory, not preferred situation, in which suitable conditions are limited. In some areas that type of distribution may occur in at least the later months of all or most winters, e.g., in the Telkwa and Caribou Mountains of central British Columbia (Stevenson and

Hatler 1985), the Columbia mountains in southern British Columbia (Simpson et. al. 1984) and in Mt. Edziza Provincial Park, west of Spatsizi (unpubl. data, B.C. Gov. Files). At Spatsizi, however, there were no significant occurrences above timberline in two of the four winters, and no major aggregations were documented at lower elevations. That probably reflects locally superior climate and habitat conditions , and may help to explain why the Spatsizi area population is among the largest in the province.

4.9 POPULATION DYNAMICS

4.9.1 General

The caribou manager needs to know whether, to what extent, and why the number of local population gains differs from the number of losses. The 1980-84 Spatsizi studies have focussed more on providing the background for gathering and interpreting population facts than on gathering the facts themselves. Therefore, although sufficient relevant information has accumulated (3.9) to warrant highlighting and some discussion, a full development of the topic of population dynamics in the Spatsizi area is not yet possible.

4.9.2 Natality

Animals tend to produce their young at a time when environmental conditions are optimal for survival of mother and young (Sadlier 1969). Early June is the optimal period for caribou in the Spatsizi area and apparently also for several other mountain-dwelling populations, including those in southeastern British Columbia (Simpson et al. 1984, Johnson and Miller 1979) and western Alberta (Edmonds and Bloomfield 1984), although those reports give little specific data. The peak of calving also occurs in early to mid-June in populations of barren ground caribou (Kelsall 1968). For the Porcupine herd, the peak is given as 6 June, while that for mountain-dwelling woodland caribou that share portions of the Porcupine herd's winter range in at least some years is apparently 2 weeks earlier (21-22 May, Farnell and Russell 1984). Woodland caribou over most of their range appear generally to calve earlier than those in Spatsizi, by a month or more in the boreal forests of northern Manitoba (Shoesmith and Storey 1977, Darby and Pruitt 1984) and northeastern Alberta (Fuller and Keith 1981) and by 2-3 weeks in the barrens of Newfoundland (Bergerud 1975).

Sadleir (1969) stated that the timing of breeding is a consequence of gestation in relation to the optimal period for birth. That is, environmental conditions pertaining during the locally selected birth period constitute the ultimate cause for the timing of birth, and therefore also for the rut. Unfortunately, it is not clear what environmental conditions are the most important ones for caribou. The best approach for identifying them would appear to be in comparisons between areas with different calving times, as outlined in the previous paragraph.

Holthe (1975) compared three populations of wild reindeer occurring at the same latitude in Norway, but having calving peaks at 6, 12 and 28 May. His examination was not exhaustive, but he generally eliminated phenology, genetics and population composition factors. There appeared to be some relationship to degree of disturbance during fall hunting, but the factor he appeared to favor was nutrition. The animals on the best range bred and calved earliest, and those on the poorest range were latest. Nutritional status is suspected to alter gestation length; McEwan and Whitehead (1972) showed an approximately 10 day shorter gestation for captive caribou, raised and maintained on a high nutritional plane, than for their wild counterparts, and Bergerud (1975) documented a tendency to later calving peaks following severe winters. However, it does not follow that the populations with the latest calving periods are those with the poorest nutrition. The large body and antler sizes indicated for Spatsizi animals, which have among the latest calving season recorded, speak for exceptionally good nutritional conditions in that area.

Apparently no rigorous analyses have been done on the potential for weather factors to act, in whole or in part, to select the local timing of calving. It is generally acknowledged that conditions in calving areas at calving time are characteristically severe (Kelsall 1968, Bergerud 1980), and it has been observed that animals are born then in spite of those conditions. Over the long term, however, there may be brief periods that provide the best average conditions. For example, the 1-10 June period in northern British Columbia has averaged drier than other 10-day periods in summer for over 25 years (Fig. 3). If selection has been on the basis of a particular weather pattern, then occasional departures from that pattern could result in reduced calf survival (see Miller and Broughton 1974). That is particularly true given the short period when most calving occurs (e.g., see Bergerud 1975). More specific information is needed on the peak of calving for the Spatsizi and other upland populations, to enable further analysis of the relationship between the timing of calving in relation to weather patterns.

Overall there is evidence that the Spatsizi animals, and perhaps other caribou that move to high altitudes in summer, have a calving season approximating that among animals that move to high latitude in summer. The Spatsizi animals are also like their arctic counterparts (Kelsall 1968) and the woodland caribou of Newfoundland (Bergerud 1975) in having a relatively short, compressed calving period. There is evidence that calving may be less synchronous for some of the woodland caribou that live year round in the boreal forest (Shoesmith and Storey 1977, Fuller and Keith 1981, Darby and Pruitt 1984).

Female caribou generally have their first calves when they are three years old (Bergerud 1980), although Davis _et al._ (1983) reported successful calving by six of nine radio-collared 2-year-old females in an Alaskan herd. The Spatsizi caribou may fall into the general pattern, not maturing early despite good nutrition and their resulting large body size. The single, fall-captured yearling (B17) did not give birth the following spring, and only one of two 3-year-olds produced calves. Two other females were known young, but tooth ages were not obtained. One of the smallest females captured (B24) was thought to be no older than two at the time, although she had a calf at heel. She failed to produce a calf the following year. Number C38, believed 2 years old when captured in June 1983, was non-parous at that time and was also apparently barren in 1984. Some older

Spatsizi females did not give birth every year, some were apparently post-reproductive individuals, and a few others may have been chronically non-reproductive.

Despite the above evidence that some aspects of productivity might be below average at Spatsizi, there is conflicting evidence including several observations of apparent twins (3.9.2.3). Extensive observations have failed to turn up incontrovertible proof of twinning in most barren ground caribou herds (Kelsall 1968, Dauphine 1976), and the only apparent sighting is that of McDonald and Martell (1981). However, twins have been reported for free ranging reindeer in northern Canada (Nowosad 1973) and from a captive caribou (McEwan 1971), and Shoesmith (1976) found twin fetuses in a Manitoba woodland caribou. The captive and reindeer twins were smaller than normal and did not survive well. Nevertheless, Shoesmith (1976) reflected on the enhanced breeding potential that his finding might represent.

The possible twinning observations at Spatsizi could have involved temporary adoptions of extra calves by some females, but that seems less likely in the dispersed, isolated distribution described for Spatsizi caribou in summer than might be the case for animals that gather in large, potentially confusing post-calving aggregations. All observations were in 1983 and 1984, following two relatively mild winters; especially under such conditions, woodland caribou may have a higher twinning potential than has been thought previously. More detailed observations at calving are required.

In 1983 and 1984, when the sample was large, only 68-75% of the collared females were known or suspected to have had calves, as compared to a mean of 82% listed by Bergerud (1980) for eight other North American herds. That difference indicates the need for more information on the relative productivity of Spatsizi caribou. Since age at first reproduction is potentially an important factor, and one about which we know little in woodland caribou (Stevenson and Hatler 1985), more young females should be collared and observed, and better information on the age structure of females in the population is required.

4.9.3 Calf Mortality

Calf mortality is a major caribou issue in British Columbia. The general hypothesis is that predation on neonates is the major limiting factor for the species (Bergerud 1978, 1983; Bergerud et. al. 1984a,b). Although evidence from elsewhere, e.g., Davis et. al. (1983) and Miller et. al. (1983) indicates that the hypothesis is tenable, preceding sections have indicated that there may be serious flaws in the data upon which previous conclusions for the Spatsizi area have been based. Among the most important of those are the potentially biased fall recruitment assessments on the major rutting areas (4.2.4), and biased spring calf mortality figures based on the unrepresentative summer gatherings of caribou at Fire Flats (4.2.8.2).

The previous section indicated that initial production at Spatsizi may be lower than normal for caribou. Thus, some of the apparent loss of recruitment documented by composition counts in fall or winter may be explainable at that level. Nevertheless, observations of the collared females have confirmed that calves are indeed lost during the summer. There have been no opportunities to determine causes. Since helicopters were available for close observations only in mid-June and early October of 1983 and 1984, even the timing of losses is uncertain, although there is an indication that most were in about the first month of life (Table 16).

A comparison of calf survival between 1983 and 1984 is of interest in relation to the hypotheses of Bergerud et al. (1984b) and Bergerud and Page (in press). The former authors argued that a) the animals disperse widely to solitary calving areas as an antipredator strategy, and b) it does not work. Their explanation for point b, referring to the Spatsizi area specifically, is that "...there are now too many predators searching per unit area". The latter authors invoke an interaction with weather, suggesting that predation is more successful in late springs, i.e., when snowfree areas at high elevation are scarce.

The 1982-83 winter was mild and the 1983 spring was early, potentially allowing the greatest dispersal and most frequent use of snowfree alpine habitats in that year. Spring was very late in 1984, resulting in a more restricted total distribution and a greater use of calving habitats below timberline. The hypothesis would predict greater survival in 1983, when the greatest dispersal and highest use of the allegedly preferred habitats occurred. However, calves of collared females survived to October at least five times better ($p<.01$) in 1984 than in 1983 (Table 16). On a per-100-females basis, October calf ratios in the collared sample varied similarly between years (1984 = 5 x 1983, $p<.05$, see 3.9.2.4). However, the 1984 calf ratio was only slightly better than that in 1983 as measured by the fall count sample of the general population (Table 18). The reason for the extreme difference between those two samples is not known, but will be examined in future work.

Neither the general predation nor the predation-phenology hypothesis is supported by the 1983-84 comparisons, whether based on the radio-collared data or on that from fall counts of the general population. There is no direct evidence and no reason to suspect that wolf or bear numbers differed greatly between 1983 and 1984, and there are no data on the abundance of other potential predators. However, there was a conspicuous climatic difference. The summer of 1983 was much wetter than that in 1984, including 360% more precipitation during the 1-10 June period when most calving occurs, and 455% more in July (Table 1). The possible significance of wetness at calving was described previously (4.1), and it has been shown that the past decade, during which recruitment has apparently been relatively low, has been characterized by the consistently wettest early Junes in 35 years, as recorded at Dease Lake (Fig. 3). Significantly, the series of driest early Junes among those records occurred in 1965-69, immediately prior to the postulated peak for caribou populations in British Columbia (Bergerud 1978, Bergerud *et al.* 1984a). Although demonstrating that predators have been responsible for a large proportion of calf losses in two barren ground caribou herds, Miller and Broughton (1974) and Miller *et al.* (1983) have nevertheless suggested that weather factors may be important in some years. As indicated above, there is evidence that significant weather effects on neonates can not yet be ruled out in British Columbia either.

4.9.4 Adult Mortality

Mortality of the collared adults in the Spatsizi area was variable from year to year, ranging from 3.7% (N=27) in 1982-83, the year with the mildest winter, to 42.9% (N=7) in 1981-82, the year with the severest winter. Assuming that the collared sample is representative, it is evident that weather conditions can greatly affect the rate of losses. At least three of four mortalities documented in the 1981-82 winter apparently resulted from causes other than predation or accidents. During the first 4 years, the adult mortality rate averaged 12.8% for females and up to 14.9% overall. The degree to which that reflects mortality in the rest of the population depends upon the comparative age structure of the population versus the collared sample. The collared animals were generally old (3.2.1), thus possibly more likely to die.

There is little comparative information on adult mortality in the literature. Edmonds and Bloomfield (1984) reported 19-22% natural mortality rates of collared animals in their western Alberta study areas, with the majority occurring on summer range for the mountain-dwelling population. They implicated predation as the major cause, citing the season of greatest mortality (summer) as one bit of evidence. In comparison, during the 4 years of study at Spatsizi there were no adult losses in summer; indeed, all occurred during the 5-month period, January-May (Figure 16). As was also found by Reimers (1983), most adult female deaths were in spring.

Fuller and Keith (1981) calculated 15% annual adult mortality in their northeastern Alberta study area, based on losses of four animals over a 2.5 year period. Predators were known to have killed two of those four. Simpson *et al.* (1984) reported a 25-33% adult mortality for their collared caribou, but that appears to apply to a period of at least 2 1/2 years (their Table 12), thus the mean annual rate based on monitored animal years would be considerably less than that.

In recent years, biologists have been monitoring mortality of radio-collared caribou in several Alaska caribou herds. Most results so far have been presented only in preliminary reports, but observed mean annual natural mortality of adult females has generally been low, 1.6% to 5.8% in the Delta herd (Davis and Valkenburg 1984) and 4.1% to 7.7% for the Western Arctic Herd (Davis and Valkenburg 1983). Bergerud (1980) calculated adult mortality rates of 7-13% for eight North American herds, based on comparisons of census results.

The results discussed above suggest that woodland caribou populations may experience higher mortality rates than the species generally, particularly in comparison with the barren ground animals of Alaska, and that the Spatsizi population may have the best adult survival of the woodland caribou studied. However, sample sizes in most areas have been small. Clearly, more work on the timing and causes of mortality in caribou populations is needed. Martell and Russell (1983) have described the problems associated with the purely arithmetic determinations of mortality, and have suggested that monitoring cohorts of radio-collared animals may produce the best estimates overall. A more complete pool of such data is needed, at least initially, to establish order-of-magnitude and to enhance interpretations of data from the other sources.

4.9.5 Population Status

The general Spatsizi area population has probably been increasing since at least 1983, but there may have been high mortality during the 1981-82 winter, when three of seven collared animals died (3.9.5). Taken at face value, the official total counts between 1977 and 1984 (Table 17) do not indicate any certain population trend. It could be concluded that there was a major decline after 1977, but it is also possible that the high count in that year was due to some set of favorable circumstances that a) put a higher than usual proportion of local animals in the uplands surveyed, b) concentrated animals to a greater degree than usual (see Ramey 1984), and/or c) brought animals in from rutting areas elsewhere.

Potential difficulties with the measurement of recruitment by fall counts have been described or implied on several occasions in this report. Since many females with calves do not attend the major rut concentration areas, it is apparent that actual recruitment has usually been better than that indicated by the rut counts. One indication of how much better is given in Table 17, in a comparison with opportunistic counts later in the year. A count in January 1981 gave a calf ratio that was 7.3% higher in absolute terms and 58% higher in relative terms than the official count the previous fall; counts in early March 1982 and November 1982 were 9.9% and 4.8% higher (absolute) respectively, than those in the previous October surveys.

However, those later counts may also be biased. The proportion of bulls among the late fall and winter groups was not known.

A more complete analysis of past survey results, circumstances, and implications, including consideration of whether counts on the individual rutting areas can be meaningfully compared from year to year, is presented in a separate report focussing on inventory (Hatler, in prep.). Regarding the Spatsizi population, the tentative conclusion is that wrongly timed surveys and misinterpretations based on inadequate local knowledge of life history have resulted in status statements that were more pessimistic than warranted. Although there may have been some decline between the early and mid- to late 1970's, and it is is apparent that the population has not been producing at the species' full potential, it is unlikely that the situation was as bad as portrayed previously (see Bergerud 1978; Bergerud and Butler 1978).

5. SYNTHESIS

5.1 INTRODUCTION

Most of the information on caribou in British Columbia is from incidental observations, scattered both in time and space (see reviews by Bergerud 1978 and Stevenson and Hatler 1985). There have been a few short-term local studies, but those providing life history data for even one full year have been few, and only from the southeastern quarter of the province: Wells Gray Park area, based on observations of unmarked animals, (Edwards and Ritcey 1959); Revelstoke area, small sample of radio-collared animals (Simpson et al. 1984). The present study is the first involving the "northern caribou" of Stevenson and Hatler (1985), and the first to monitor more than five known individuals for more than one year. The purpose of this section is to draw on the experience gained and data accumulated to provide a generalized preliminary picture of caribou life history in northern British Columbia, and briefly to assess previous studies in the Spatsizi area.

5.2 THE ANNUAL CYCLE OF SPATSIZI CARIBOU

Based on findings presented earlier, Figure 17 provides a simple representation of the annual cycle for caribou in the Spatsizi area. Appendix 14 outlines the general activities, habitats, and aggregation tendencies applying to each of the major seasons shown, and indicates known differences in patterns resulting from differential predilections between classes of animals or differing environmental conditions. The potential for inventory and capture of research animals is also briefly

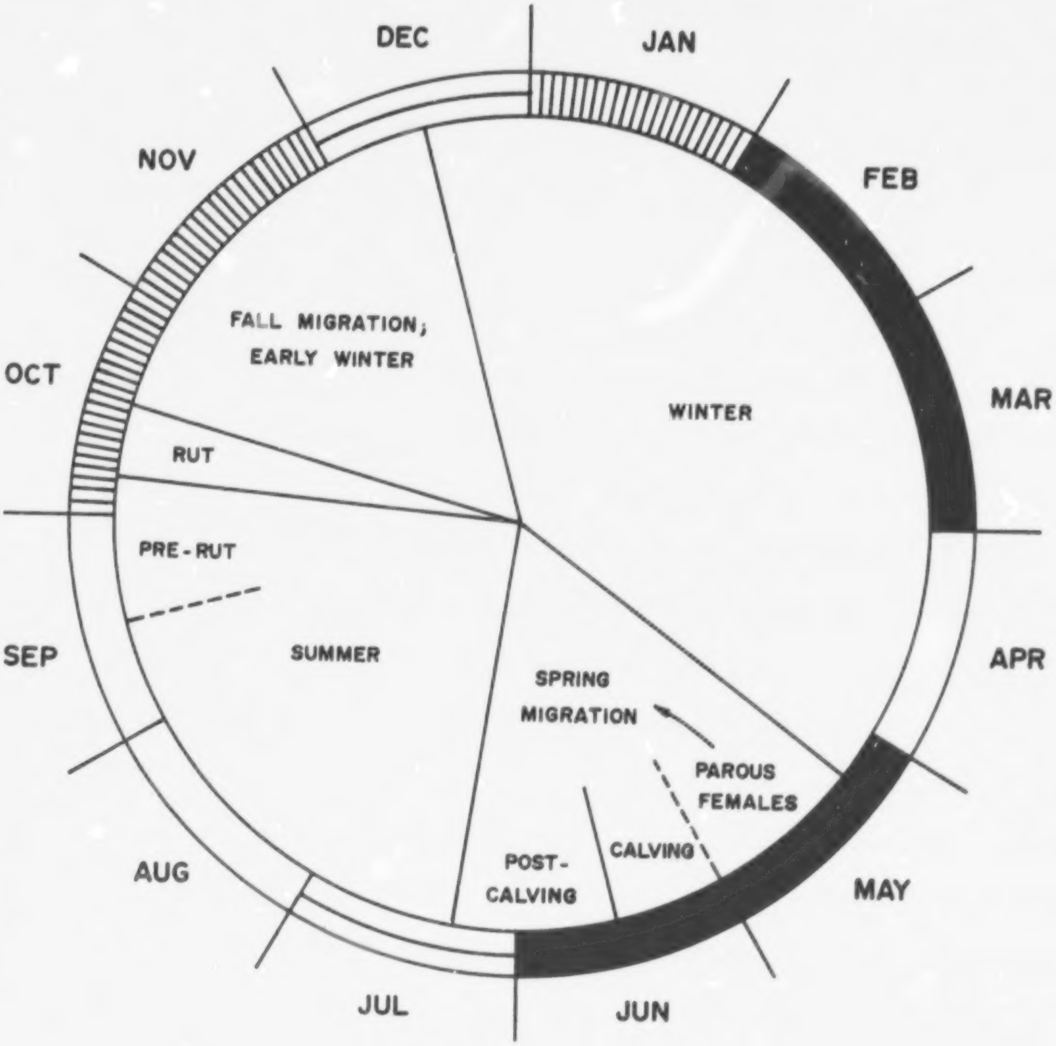

FIG. 17. ANNUAL CYCLE OF CARIBOU IN THE SPATSIZI WILDERNESS PARK AREA, BRITISH COLUMBIA.

Outer ring shows number of radio-tracking flights in each month over the four-year period 1980 - 84:

1 - 2 ☐
5 - 6 ▥
3 - 4 ☰
7+ ■

considered for each period, and data gaps and major questions still existing are identified.

The Spatsizi caribou differ from mountain dwelling woodland caribou in southeastern British Columbia in being more truly migratory, moving some distance between winter and summer ranges rather than just locally up and down slope, but the general calendar of events seems to be similar for the two areas (see Simpson _et al._ 1984, Johnson and Miller 1979). The pattern of movements in Spatsizi during deep snow winters may approximate that in the mountains of southeastern British Columbia in all winters, although the descent to spring range is probably later in Spatsizi in most years (May vs. April). The Spatsizi annual cycle appears almost identical to that described for caribou in western Alberta, including both animals that moved to summer ranges in the mountains and those that remained in the forested foothills (Edmonds and Bloomfield 1984). For the migratory woodland caribou of Newfoundland, the spring migration apparently commenced 4-6 weeks earlier and calving was somewhat earlier than at Spatsizi, but other events and times were about the same in the two areas (Bergerud 1974). The woodland caribou in the boreal forest of northeastern Alberta (Fuller and Keith 1981) and northern Manitoba (Shoesmith and Storey 1977) appear to be a month or more earlier than Spatsizi caribou in spring migration, calving, and rut, and may have no movement comparable to the fall migration described for the Spatsizi and other areas. However, conclusions for the forest animals have been based on small samples of radio-collared animals and pertinent sightings of unmarked animals have apparently been rare.

Generally, the annual cycle of migratory woodland caribou in mountain habitats is more similar to that of barren ground caribou (Kelsall 1968), than of woodland caribou in non-mountainous areas.

5.3 POPULATION DISTINCTIONS

Stevenson and Hatler (1985) described several problems in the management of caribou in southern and central British Columbia, and noted that "Overall, the initial need is...identification and description of the actual populations present, as defined by biological rather than geographic criteria". They were referring to management that is based on administrative boundaries established without particular reference to, or more than general knowledge of, caribou distribution and population boundaries. This section constitutes a first approximation at defining and describing separate groups in the Spatsizi area. It is based on the radio-tracking results presented earlier, with particular reference to seasonal movements, distribution and dispersion in relation to individual homing tendencies, as developed in Hatler (1985a).

All but two of the animals radio-collared for this study were captured on or near the northernmost rut survey area, known locally as Caribou Mountain (see Figure 1). That area is now known to be a concentration area during the fall migration/early winter period (3.6.1), when most of the captures were made. Therefore, the instrumented animals included not only individuals that had rutted on or near Caribou Mountain but also others that had recently migrated from rutting areas elsewhere. Most of the collared animals have wintered each year in the same general area, centering on the lower Stikine Valley along the northern boundary of Spatsizi Park. In summer, they have dispersed from that area in all directions, but mostly southward (3.6.3).

Repeated observations have demonstrated that, despite their relatively close association in the Caribou Mountain area in November and in the Stikine River Valley area for the remainder of the winter, the collared animals do not function as a group all year. Individuals differ in the extent of their movements to the summer area, and therefore in the sizes of their annual and total home ranges, and they also vary in their degree of fidelity to the summer area.

Home Range Patterns - The home range data, although variable between individuals (4.3), produced the first evidence of separate summer range affinities in the area. Comparing the two late fall captured cohorts of instrumented animals (Fig. 1), the 1982 animals had much larger mean annual ranges than the 1980 group. Further, many of the cumulative 2-year ranges for the 1982 cohort equalled or exceeded the 4-year ranges for the 1980 animals. It was evident that the distance between the winter and June location, i.e., the length of the spring migration, was the primary factor contributing to the differences in home range size. The smallest ranges were for those animals that remained in the general vicinity of the Spatsizi River drainage above Hyland Post and the drainage of the lower Stikine River below its confluence with the Spatsizi. Intermediate-sized ranges were recorded for those in the upper Ross/upper Stikine areas, and the largest ranges were for outliers and individuals with no apparent attachment to a particular early June location. The observed difference between cohorts can be explained by the differences in timing between the 1980 and 1982 capture expeditions in relation to the post-rut migration described earlier. Most of the 1980 captures were earlier than those in 1982, thus biasing the sample to a greater degree to those individuals that had summered and/or rutted nearby.

Fidelity to June Location - The factor that insures the continuity of the home range size pattern described above is the tendency for individuals to return to the same area each spring. That tendency appears to be greatest for parous females, but at least some barren females and males behave similarly (3.6.5).

Relationship of June and Rut Locations - Summer range, which has been distinct from winter range for most individuals, includes both the calving and rutting locations. One important exception involves females that are barren or have lost calves. Many of those move earlier and farther in summer than do successful mothers, and may appear in rutting groups in other summer ranges, especially those to the north.

Figure 18 provides a preliminary picture of separate calving/rutting distributions in the Spatsizi area. From one general wintering association there are at least three separate summer groupings. The first group averages the shortest movements, perhaps mostly south and west into the Eaglenest Range and Upper Spatsizi River drainage. Provisionally, outlying animals in the east (between the Pitman and Chukachida Rivers), the north (between the McBride and Tucho Rivers), and the west (Klappan-Upper Nass) are included in that group, although larger samples of collared animals and more observations during rut may show that each of those are also separate. The second group consists of animals that move at least 50-60 km south from the winter range in summer, and occupy uplands in the Upper Ross and Upper Stikine River watersheds, and probably also that of the Upper Skeena. A third group, involving the longest distance movers, apparently occurs in summer in the Metsantan-Lawyers Pass area and probably in at least northern Tatlatui Park. The nature of occurrence in that area is still less clear, because there have been few collared animals. Some individuals from that southernmost group are known to move north to the lower Stikine wintering area, but some wintering also occurs in the Finlay drainage in some years (personal unpubl. data).

Conclusion - The emerging picture is that the homing tendency of many individuals in spring and subsequent local movements in summer result in maintaining adjacent rutting groups that remain largely separate. As used here, "rutting group" refers to all of the animals rutting within a particular summer range, and not just those on the designated rut survey areas. That is, they are not necessarily all in one location during the rut. There appear to be at least three such groups in the Spatsizi-Tatlatui Park area. Whether those essentially separate groups constitute "populations" in the sense of distinct units for management and/or research is as yet unknown. The term "herd" as used to refer to a group of barren ground caribou sharing a common calving ground (Kelsall 1968, Calef 1978) and by

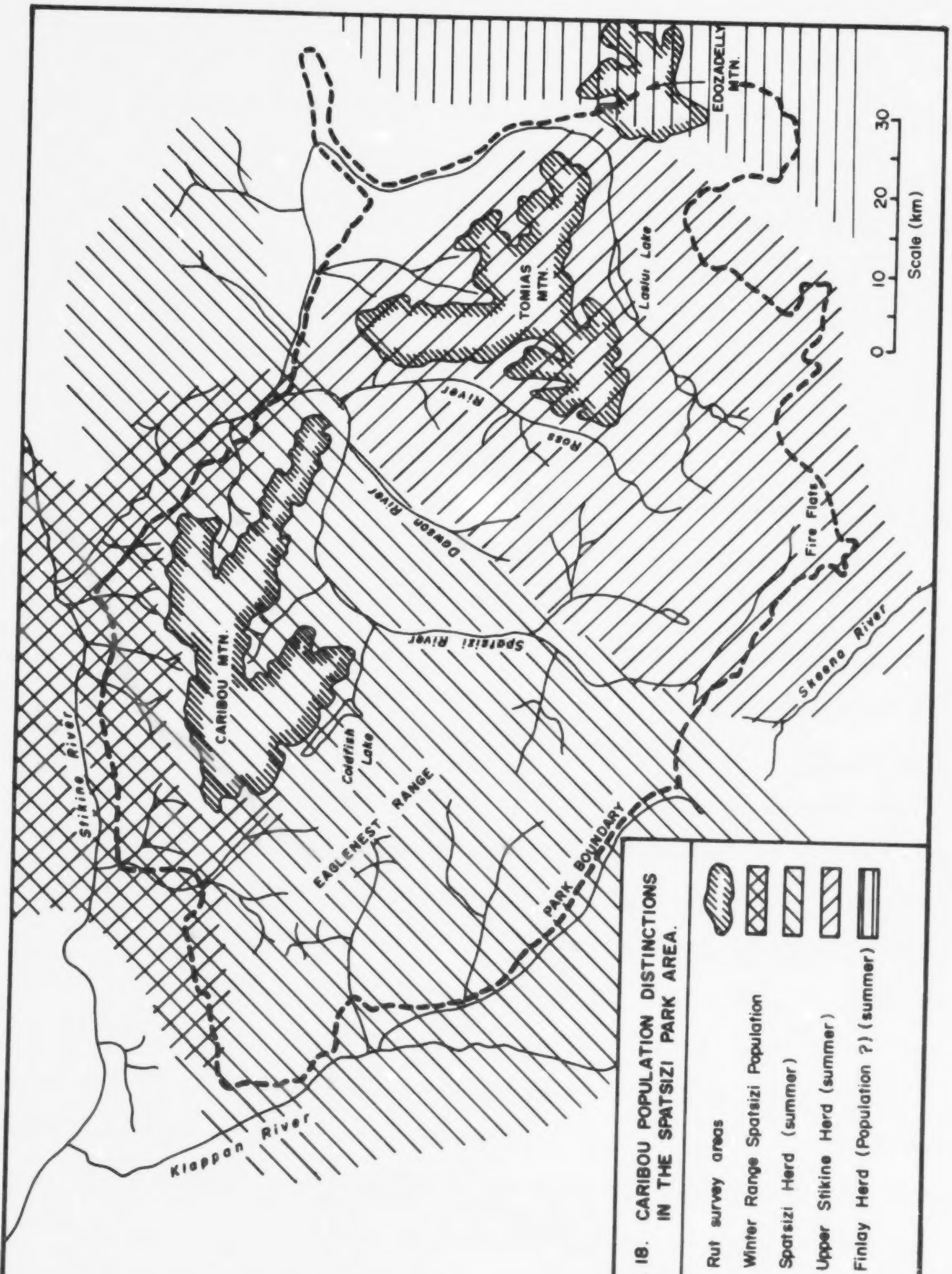

FIG. 18. CARIBOU POPULATION DISTINCTIONS IN THE SPATSIZI PARK AREA.

Rut survey areas
Winter Range Spatsizi Population
Spatsizi Herd (summer)
Upper Stikine Herd (summer)
Finlay Herd (Population ?) (summer)
EDOZADELLY MTN.
TOMIAS MTN.
CARIBOU MTN.
Laslui Lake
Coldfish Lake
EAGLENEST RANGE
PARK BOUNDARY
Stikine River
Klappan River
Ross River
Dawson River
Spatsizi River
Skeena River
Fire Flats
0
10
20
30
Scale (km)

Bergerud (1978) to refer to particular rut area associations of British Columbia caribou would seem a better choice, with "population" referring to the collection of herds sharing a common winter range. With that definition, the Spatsizi population overlaps all of two provincial parks and portions of at least six management units in three administrative sub-regions of the province.

5.4 REVIEW OF OTHER SPATSIZI STUDIES

A number of researchers have previously reported on Spatsizi caribou from either incidental observations or specific studies. The pertinent references through 1985 are here assembled together for the first time, and are categorized, highlighted and briefly assessed in the light of findings presented earlier:

Incidental Observations - While observing mountain sheep in the vicinity of Gladys Lake, Geist (1971) occasionally saw caribou and was the first to report high elevation calving in the area. Carswell (1975) also saw calving females in the Gladys Lake area, and provided the first written record of the summer concentration at Fire Flats. The only intensive vegetation studies in the Spatsizi area, the basis for all habitat descriptions in the present study, were conducted in the Gladys Lake Ecological Reserve (Pojar 1977, 1984).

Inventory and Data Review - The official resource inventory for Spatsizi and Tatlatui Provincial Parks (Osmond-Jones et al. 1977), was based on a review of government file information and the results of field studies in summer 1976. Their report appears to be the first to describe and express concern for low caribou calf ratios in the area, mostly measured in summer and fall concentration areas now known to be disproportionately used by successful mothers. The authors nevertheless correctly distinguished between the small maternal bands in the mountains and the large groups with few calves elsewhere, and correctly speculated that winter habitat use varies with snow conditions. They also identified the fall concentration areas where rut surveys have since been carried out.

Based on four systematic transects from fixed-wing aircraft in 1976-77, Boonstra and Sinclair (1984) confirmed some previous knowledge about seasonal distribution in the Spatsizi area. However, their conclusions about seasonal habitat selection were generally either incorrect or oversimplified, probably because of the great visibility bias for animals in open versus coniferous forest habitats. In a report that has had considerable impact on caribou management and research in British Columbia, Bergerud (1978) concluded that the Spatsizi population was in severe decline. He had limited data of variable quality to work with, therefore his conclusions are not well supported. A detailed critique of his Spatsizi comparisons is presented elsewhere (Hatler, in prep.). Haber (1979) presented another review of caribou population data for the area. He questioned population trend interpretations from rut survey data, suggesting that previous researchers had "...under-rated the possibility of spatial shifts". Importantly, he emphasized the need for accurate population data and for extensive telemetry or visual marker studies to identify the separate groups of caribou in the area.

Ecology Studies - A progress report based mostly on field studies during the summer of 1977 (Bergerud and Butler 1978) and its formal elaboration (Bergerud _et al._ 1984b) are particularly important documents both because they have influenced management and research in the province, and because they have been cited as major support for subsequent papers on population regulation in caribou (Bergerud 1980, 1983; Bergerud _et al._ 1984a).

Although a full critique can not be provided here, data collected during the present study conflict with many of the assumptions and conclusions of Bergerud and his associates. For example, the telemetry data suggest that their information on numbers and recruitment is unrepresentative (4.9.5), their characterization of calving and other seasonal habitats is biased to open areas in which animals are most readily seen (4.7.3), and their use of unsystematic data has resulted in an erroneous generalization about movement and aggregation patterns of females in summer (4.8.2). They provide no direct data to support their statements about fall rut concentration areas, i.e., that they might be the most important seasonal habitats, or that counts from particular rut survey areas approximate total counts for local "herds", and the telemetry results do not support either.

Finally, although their major conclusion is that predation is the local limiting factor, their evidence is mostly indirect, and one statement about predator occurrence is misleading; a reference to sightings of "...12 wolves, 12 grizzly bears, 1 black bear and 3 wolverines" (Bergerud _et al._ 1984b) actually refers to the number of sightings rather than to the number of different animals seen during their study. A subsequent telemetry study of calf mortality in the area (Page 1980) provided little additional support for the predation hypothesis, primarily because of small sample size and infrequent monitoring.

Lacking the perspective provided by repeat observations of known individuals over more than one annual cycle, Hatler (1983) speculated that all of the caribou in northern British Columbia might constitute a single population. It is now evident that there are separate herds in the Spatsizi population, and the area possibly supports separate, adjacent populations as well (5.3, Hatler 1985a).

Management Considerations - The initial indication that the standard fall rut surveys might underestimate recruitment was presented by Hatler (1983). Subsequently, Hatler (1985b) emphasized the importance of inventory to management, described ongoing inventory development and evaluation activities in the Spatsizi studies, and provided additional evidence for biases in fall rut counts. Ramey (1984) analyzed data from a series of Spatsizi rut surveys and showed an inverse relationship between group size and the proportion of calves. Despite the apparent deficiencies in fall rut count data, Jones (1985) outlined a logical approach to interpreting and applying it in a program of conservative harvest management.

Consultant Studies - Some proposed industrial developments near Spatsizi Park have been perceived as potentially affecting caribou in the area, and several studies have been undertaken in recent years. In their attempts to interpret the regional significance of particular local habitats or occurrences, all have been hampered by a lack of specific information on population or herd distinctions, as documented by the movements of marked animals. For the Kutcho Creek area, north of the park, Webb (1980) assumed that his study animals were primarily Bergerud's (1978) "Turnagain River Herd", but with a winter influx of the "Caribou Mountain Herd" from northern Spatsizi Park. The radio-tracking studies have shown the situation to be more complex than expected, with movements both north and south across the Stikine River in early winter, and involving animals from as far south as the upper Finlay drainage. The population affinities of animals that spend the summer and fall in the Kutcho area are still unknown.

The most intensive set of winter caribou observations in the general area, 30 aerial surveys during a 36-day period in late February and March 1980 (Wyborn 1981), was conducted as part of a feasibility study for a proposed dam on the Stikine River. The study timing was selected to document an "annual migration", apparently across the river, which was believed to occur at that time. Neither Wyborn's results nor the telemetry data from this study have confirmed the existence of such a regular, predictable winter movement.

The other studies focussing on caribou in the area (Beak 1982, AIM 1982, DeBock 1980, 1981a,b, 1982a,b,c) have all been in relation to mining prospects southeast of the park, in the Toodoggone - Upper Finlay River area. A common feature of those studies was inappropriate timing of the main field activities, with calving studies being completed before the peak of calving in all cases, and rut surveys being undertaken mostly during the pre-rut period. Some early conclusions about winter distribution and habitat use (DeBock 1980, 1981b) were drawn from observations in November, during the fall migration period. The only actual winter observations were in late March of 1981 (Beak 1982) and 1982 (DeBock 1982a), i.e. at the ends of two severe winters (4.1). Conclusions that the animals winter in alpine habitat and that few occur in the upper Finlay drainage in winter are no doubt appropriate for those years but, as shown by subsequent telemetry studies, they are not accurate as generalizations.

Another feature of the Toodoggone studies, and also of Webb (1980), was preoccupation with the rut, apparently based on a statement by Bergerud and Butler (1978) that "Rutting ranges may be the most critical and weakest link in the habitat cycle for caribou." In the context of that conclusion, which is not supported by the telemetry results, a proposed development is assumed to have low impact on a local caribou population if it does not occur on a "critical" rutting area. An important contribution of AIM (1982) is documentation of the day-to-day variation that may occur in successive fall counts on rut aggregation areas. That result is further evidence that surveys designed to assess local populations by single counts on fall rut areas risk underestimating the number of animals actually present.

5.5 SOME MANAGEMENT AND RESEARCH IMPLICATIONS

Preceding pages have presented and discussed a variety of findings relating to the biology of caribou in the Spatsizi Wilderness Park area of northern British Columbia. Many of those findings suggest the need for management actions or additional research, but some are more important than others. The purpose here is to highlight findings that require attention and consideration now. as distinct from those which are merely interesting or promising.

Habitat- Although local seasonal habitats have not yet been fully described, they have at least been identified. The habitats that had been best known previously were the rut concentration areas and, probably because they were the best known, there was a tendency to consider them as particularly significant centers of distribution and the basis for group distinctions (see Bergerud 1978, Bergerud and Butler 1978, Webb 1980, Beak 1982, AIM 1982). The radio-tracking studies have not confirmed that those rut areas are of primary importance. Not all animals attend them, and there is evidence that use of specific locations may vary both within and between seasons. In general, habitats selected by the caribou between late May and mid-October are the most variable and widely scattered in the annual cycle, an expression of diverging individual traditions when environmental limitations relating to such factors as snow cover and food availability are fewest. That is, the distribution during that period appears to be largely a matter of "choice" in some non-rational sense. On the other hand, the post-rut movement from all directions back to the general vicinity of the lower Stikine River Valley, the most conspicuous demonstration of converging individual traditions in the study area, appears to be a matter of obligation.

Simply stated, the lower Stikine winter range appears to be the most important single area used by the Spatsizi caribou population.

Critical Habitat- This term seems to be more political than biological, relating to a general public desire to identify the minimum areas required for management of a species in order to maximize the area then available for other purposes. Biologists generally attempt to identify such areas by noting where the animals go when they have run out of options, and at higher latitudes that usually occurs under severe winter conditions. In the Spatsizi area, and apparently elsewhere judging from the literature, caribou move to upland habitats when they have difficulty subsisting in the forest. At Spatsizi, winter occurrence in the alpine zone represents a forced, stressed situation, during which animals may be dying. To consider the alpine areas as the critical range needing protection would be a serious misinterpretation. If the objective is to maintain a large, viable population, the large area that normally supports large numbers of animals over the bulk of most winters must be more critical over the long-term than are a few last-ditch survival areas.

If there are any relatively small areas that can be properly classified as critical, they would probably be some of the lowland migration corridors through which a large proportion of the population may travel, especially in spring.

Impact Assessments - An important finding in the Spatsizi studies is the variation in distribution and behavior among individuals and between years. One-time surveys and/or short term studies are not adequate to define local patterns. Unless results of such studies can be viewed from the perspective provided by a series of longer term observations, preferably over much of the range of climatic variations that can be expected, they may actually be detrimental to habitat protection efforts. That is, a little bit of information is not necessarily better than nothing, and may be worse. For example, from findings during the first year of the Spatsizi radio-tracking studies one might have concluded, as DeBock (1982a) did for the Toodoggone area, that the winter range of caribou there is in alpine habitat (see Hatler 1983), and an incorrect decision to facilitate industrial developments in local lowland forests could have been made accordingly.

Many of the field activities for impact assessments in the general Spatsizi area were conducted at inappropriate times relative to specific events in the annual cycle (5.3). That is another consequence of operating with inadequate local background and perspective. Impact studies are always specific to location, but are often too general in purpose, failing to properly account for temporal as well as spatial components in the life cycle of a local population of interest.

Finally, monitoring radio-collared animals has shown that some published conclusions about caribou habitat selection in northern British Columbia have been biased in favor of open areas, thereby setting the stage for inappropriate survey activities and misinterpretations in any local situation. For example, upon reading in Bergerud et al. (1984b) that caribou in the Spatsizi area "calve on high south slopes", one might design a local survey searching only such areas, or might conclude that a proposed development that is not on a high south slope can not conflict with calving. The primary point here is that whether from the literature or from surveys, conclusions based solely on visual contacts with woodland caribou in the area are subject to serious biases.

Summer Range Considerations - Given the peak dispersion of the animals in summer, there is a potential for negative effects far from known concentration areas. Such effects could be piecemeal, resulting from interruption of local traditions here and there, or might result from effects on larger numbers of animals in some common migration corridor. Since the summer range traditions appear to be strongly developed at the individual level, it is important to consider how they become established. In this radio-tracking study and also in a similar one in western Alberta (Edmonds and Bloomfield 1984), different caribou groups were distinguishable on the basis of different summer movement tendencies. Whether those tendencies are phenotypic expressions or merely result from learning by young animals as they follow their mothers or other adults to summer ranges, there are some important management implications. As listed in Hatler (1985a), they include the following:

a) Animals with a tendency to move long distances from the winter range are probably most vulnerable to human impacts due to increased likelihood of contact, especially in the case of linear developments such as roads, railroads and reservoirs. It is possible that many of the apparently sedentary groups of caribou in southern B.C. are remnant populations in which the movers have been selected out.

b) Overall population size probably can not be maximized without movers in the populations; therefore management goals of increase may not be realizable for some populations in some areas.

c) Transplant efforts may fail if sedentary types are moved to areas where movers are required, and vice versa.

d) If the selection of a summer location is learned by following the mother, early summer human activities that affect calf survival may interrupt and destroy local traditions.

Population Distinctions - Radio-tracking adult females appears to be the best current method for defining separate local groups of caribou. The strong homing tendency of many individuals in the spring and subsequent local movements in summer result in maintaining adjacent subpopulations that remain largely separate. There appear to be at least three such groups, here termed herds, in the Spatsizi-Tatlatui Park area, although a larger sample of collared animals might reveal more. Provisionally, the term population is applied to a collection of local herds sharing a common winter range. Management should logically be applied at either the herd or population level, but that may initially result in some administrative and jurisdictional problems. The Spatsizi population, as defined in this report, overlaps two provincial parks and portions of at least six management units in three administrative sub-regions of the province.

Population Dynamics- Observations of the radio-collared Spatsizi animals have given reasons to doubt many aspects of the dramatic decline scenarios produced for northern British Columbia caribou populations in previous studies. It now appears that past recruitment assessments may have been pessimistic as a result of unrepresentative sampling, and that annual adult mortality is much more variable than simple population models have predicted. More specific data are required, but other tentative conclusions with management implications are that a) wolf predation may not be as important a factor as had been thought, b) the population may be older, especially in the female component, than is desirable, and c) weather factors may be particularly important on both sides of the population equation, affecting both natality and mortality.

Telemetry Studies - The use of radio telemetry to study caribou has proliferated greatly in the province in recent years and that trend is continuing. Since the instrumented animals usually constitute only a small sample of the total population being studied, it is important to consider the representativeness of that sample. Based on the Spatsizi experience to date, there are important study implications relating to the planning of capture activities and knowledge of collared individuals. Following are two such considerations:

> a) the timing of capture programs should be planned to ensure a sample best suited to fulfill study objectives. For example, animals captured on winter range may or may not include representatives from an adjacent summer area that the researcher hopes to study.
>
> b) Failure to consider identifiable differences between individuals may lead to biases and misinterpretation relating to such topics as seasonal habitat selection and calving success, and reduces the opportunity to obtain potentially important incidental data on aspects of population dynamics. For females, habitat selection and movement behavior varies depending upon individual maternal status (with or without calves) and that, in turn, may be related to age. For any given year, telemetry data for individual females is greatly enhanced if both their ages and maternal status are known.

6. RECOMMENDATIONS

The research reported here suggests the need for future action. Some major recommendations are highlighted below:

MANAGEMENT

Some type of enduring protection is required for the extensively forested caribou winter range in the Stikine River Valley north of Spatsizi Park. Based on distribution of the animals, perhaps the most unequivocal conclusion arising from the radio-tracking studies is the importance of that area to most of the caribou constituting the Spatsizi population. There may be disagreement on which features make that area important, e.g., particular food quality or quantity, cover characteristics, favorable microclimatic factors, or sufficient space to avoid predators. There may also be disagreement on whether the alteration of habitat or creation of access roads has the most potential for damage. However, managers should not let academic uncertainty obscure the most important issue--much of the area was excluded from Spatsizi Park because it was perceived to have significant development potential. Some type of protection should be secured for that area before development plans are initiated. The question of why a habitat is important can be pursued only if the habitat is there.

RESEARCH

Long-Term

The radio-tracking studies of Spatsizi caribou should be continued and expanded. Ideally, future studies should involve as many of the currently instrumented animals as possible, to further document the nature and extent of individual patterns. A larger collared sample and more frequent flights are required to better document local herd/population distinctions as well as individual and group responses to varying climatic conditions.

- Future Spatsizi caribou studies should focus more intensively on population dynamics. A larger collared sample of representative age classes and the capability to investigate mortalities soon after death are required.

- The Spatsizi studies should be expanded to include other large mammals in the local predator-prey system. To better describe that system and to rationalize currently conflicting interpretations on the nature, extent and importance of predation in the area, life history and local distribution information comparable to that gathered for caribou is required for the major predators, especially wolves, and for all of the other ungulates.

Short-Term

The radio-tracking results indicate the need for several intensive studies, involving both aerial and ground observations. Following is a list of some that now seem important:

- Observations pertaining to habitat selection, calving success and early calf survival, throughout the month of June in one or more years.
- Detailed behavioral observations during pre-rut and rut to determine group dynamics and specific rut timing, as they may relate to inventory activities.
- Determination of migration patterns and routes, through repeated locations of collared animals in May and during the period October-November.
- Specific description of seasonal habitats, based on

vegetation studies in relation to mapped radio-locations.

INFORMATION TRANSFER

- A workshop or similar forum is needed to solidify various aspects of management and research of B.C. caribou. Topics now seen as important are as follows:

Research: Descriptions and discussions of research techniques and objectives to standardize data gathering and thereby make results from different areas more readily comparable.

Habitat Protection: Discussions of terms of reference for environmental studies, information needs at the local level in relation to what is now known of the animals' biology, and the meaning of the term "critical habitat".

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8. APPENDICES

Appendix 1. Aspects of caribou capture and collaring in Spatsizi Wilderness Park, British Columbia, 1982-1984.

Introduction

A detailed description of the initial capture program, in late October 1980, was given in Hatler (1983). A similar program was carried out in late October - early November of 1982. Caribou were gently herded by helicopter to concealed gunners on the ground, and were darted with Palmer "Cap-chur" equipment. All caribou collared after 1982 were captured with a hand-held CODA net gun (Telonics Telemetry-Electronics Consultants, Mesa, Arizona) discharged from a helicopter. Following are brief summaries of the use of both methods at Spatsizi. They are condensed from more detailed accounts, available on request from the author.

Darting

Darts were pre-loaded with a drug "cocktail" of etorphine hydrochloride (M99) and xylazine (Rompun). In 1982, two standard dosages, one for each sex, were used:

For Females - 3.9 mg M99 plus 35 mg Rompun.
For Males - 4.8-4.9 mg M99 plus 45 mg Rompun.

No animals were weighed, so effective doses per kg body weight are not known. For animals which were satisfactorily immobilized with a single dart in 1982, induction times ranged from 7-34 minutes, with females averaging somewhat slower (17.9, SD 8.1) than males (13.9, SD 4.5). Aspects of capture success in 1982 are compared below to those in 1980:

No. Year	Darts Drives	Caribou Fired	Caribou Hit	No. Captured	Released Alive	No. Injured	No. Dead
1980	33	41	19	18	17	1	1
1982	69	83	49	36	35	2	1

	1980	1982
Capture attempts per successful capture	1.9	2.0
Darts fired per successful capture	2.4	2.4
Per cent of darted animals captured	95	73

The overall capture success was similar for the two years despite a higher incidence of failure to capture darted animals in 1982. Those failures were apparently due to drug performance, possibly resulting from temperature effects. Capture efficiency in terms of helicopter time per successful capture was nevertheless somewhat better in 1982 (1.3 hours) than in 1980 (1.5 hours).

As was also the case in 1980, during the 1982 captures one animal died directly from a dart wound. For the two drug capture programs, nine mortalities known or suspected to have occurred during the interval between capture and the first tracking flight were all probably capture-related. Three of the dead animals received detectable injuries during capture, two were under-dosed with the drug, resulting in hyperactivity and subsequent physical strain, three were old (12 years plus), and one was both old and under-dosed. In most such cases, predation was probably the proximate cause of death. One apparently under-dosed female was found the day after capture being eaten by 9 wolves.

Netting

Barrett et al. (1982) and Valkenburg et al. (1983) have adequately described the basic netting equipment and method of deployment, and have evaluated the use of that system for capture of caribou. The former authors netted 19 caribou, of which 2 (10.5%) had to be dispatched because of capture injuries. They concluded that the hand-held net gun "...has potential...for capturing large mammals throughout North America" and indicated that caribou were among the species for which it worked best. However, Valkenburg et al. (1983) lost 7 of 55 caribou (12.7%) to injuries suffered during netting, as compared to 9 of 163 (5.5%) among darted animals. They concluded that the net gun was useful in capturing darted, partially immobilized caribou, but was of limited use, alone, in capture of Alaskan caribou because "...we seldom find caribou in areas where snow is deep enough or the ground soft enough to allow us to use it without injuring caribou".

At Spatsizi, none of ten animals netted between June 1983 and June 1984 were injured, and none of the eight actually collared had died by November 1984 thus, in that sense, the netting technique without the use of drugs produced better results than did darting. Our most serious problem with the net, one which was not mentioned by the authors cited above, was escape of caribou while in a net. Of the ten animals netted, one managed to kick free in about 45 seconds, three were captured only when sufficiently entangled by second nets, one was captured when its trailing net snagged a fallen log, and one was lost. The potential for such loss is greatest when the animals are in relatively small openings in the forest. Even tightly hobbled animals can outdistance a man on foot in deep snow, and once they reach forest cover, additional netting is not possible. In the Spatsizi operations, the following rules were established to minimize the chances for further post-netting losses:

1) Caribou in terrain where escape was an obvious possibility were not netted with the last net available, i.e., at least one net was kept in reserve.
2) The net gunner remained in the helicopter, prepared to shoot another net, until another member of the crew had the netted animal under control.

In two cases, females with small calves at heel were captured by netting in mid-June. Both apparently abandoned their calves as a result. A female with a 9-month-old calf (March 1984) was seen back with the calf within an hour after being released.

Appendix 2. Characteristics of summer precipitation at Dease Lake, northern British Columbia, 1951-1984 (from daily summaries, files of Air Studies Branch, B.C. Ministry of Environment, Victoria). Data shown are number of days on which precipitation was at trace level or greater (TR), number of days with precipitation 0.5 mm or greater (DA), and total precipitation (mm) on days indicated under DA.

	June																				
	3rd - 8th			1st - 10th			11th - 20th			1st - 20th			1st - 30th			July			August		
Years	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP
1951	2	2	9	6	3	10	2	2	5	8	5	15	11	8	19	7	6	10	12	12	51
1952	2	1	1	3	1	1	6	6	31	9	7	32	14	12	57	11	11	64	13	11	78
1953	3	1	2	4	2	5	5	4	20	9	6	25	16	13	61	17	15	72	18	16	58
1954	0	0	0	3	2	4	10	8	17	13	10	21	18	12	27	18	12	49	10	2	40
Mean: 51-54	2	1	4	4	2	6	6	5	18	10	7	23	15	11	41	13	11	49	13	10	57
1955	3	2	2	5	3	3	3	1	1	8	4	4	11	5	19	18	13	81	20	15	54
1956	5	5	27	7	7	30	3	1	2	10	8	32	18	13	52	13	8	63	19	14	44
1957	3	1	2	4	1	2	7	5	22	11	6	24	20	14	48	21	12	38	15	14	58
1958	1	1	3	3	2	5	5	4	12	8	6	17	13	9	27	17	10	43	19	16	39
1959	4	0	0	8	3	3	6	6	36	14	9	39	20	14	78	22	13	25	24	20	73
Mean: 55-59	3	2	7	5	3	9	5	3	15	10	7	23	16	11	45	18	11	50	19	16	54
1960	4	2	7	7	3	10	8	5	24	15	8	34	21	12	53	14	10	26	19	12	24
1961	4	2	10	7	5	20	2	2	6	9	7	26	16	13	50	12	7	33	15	12	31
1962	5	2	16	8	5	42	6	6	19	14	11	61	22	15	92	15	7	129	23	18	108
1963	4	3	10	6	4	11	9	6	27	15	10	38	22	15	50	21	15	48	6	3	17
1964	4	1	4	5	1	4	6	5	28	11	6	32	17	9	35	27	21	53	22	15	56
Mean: 60-64	4	2	9	7	4	17	6	5	21	13	8	38	20	13	56	18	12	66	17	12	47
1965	2	0	0	5	2	10	6	1	3	11	3	13	15	7	28	15	7	13	12	8	61
1966	1	1	1	3	3	3	6	5	13	9	8	16	13	12	35	13	10	55	15	12	49
1967	0	0	0	0	0	0	3	1	3	3	1	3	7	5	17	17	15	67	14	10	36
1968	0	0	0	2	2	11	3	3	5	5	5	16	9	8	29	20	18	47	17	15	67
1969	2	1	2	4	2	14	0	0	0	4	2	14	10	7	27	23	15	46	26	20	85
Mean: 65-69	1	<1	<1	3	2	8	4	2	5	6	4	12	11	8	27	18	13	46	17	13	60
1970	5	1	1	9	3	27	1	1	1	10	4	28	18	9	42	21	13	48	25	14	41
1971	5	3	14	6	4	15	5	3	4	11	7	19	17	12	53	8	5	20	25	14	47
1972	5	0	0	6	0	0	6	6	25	12	6	25	19	10	29	20	12	81	22	15	45
1973	4	2	5	7	4	7	6	3	9	13	7	16	23	11	23	25	16	48	25	17	51
1974	4	1	1	7	3	14	7	5	10	14	8	24	23	17	68	24	15	72	15	12	42
Mean: 70-74	5	1	4	7	3	13	5	4	10	12	6	22	20	12	43	20	12	54	22	14	45

Appendix 2 (continued, page 2)

	June																				
	3rd - 8th			1st - 10th			11th - 20th			1st - 20th			1st - 30th			July			August		
Years	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP	TR	DA	PP
1975	6	3	3	9	6	10	7	3	5	16	9	15	23	13	50	25	20	71	24	17	49
1976	3	2	7	6	4	15	8	6	16	14	10	31	22	15	55	22	15	58	27	15	51
1977	6	4	7	10	8	32	6	4	13	16	12	45	26	20	62	26	20	85	14	9	50
1978	3	3	5	5	5	15	7	3	10	12	8	25	17	9	26	15	10	25	24	10	65
1979	5	4	22	9	8	37	10	8	24	19	16	61	25	20	81	23	17	69	10	7	18
Mean: 75-79	5	3	9	8	6	22	8	5	14	15	11	35	23	15	55	22	16	62	20	12	47
1980	1	0	0	3	2	9	7	2	7	10	4	16	18	9	43	26	15	128	25	22	90
1981	5	3	23	8	5	26	10	8	33	18	13	59	25	16	66	15	9	34	17	10	53
1982	3	1	1	4	1	1	6	1	1	10	2	2	13	2	2	21	11	54	21	14	86
1983	4	4	11	8	8	51	6	3	11	14	11	62	21	15	72	26	20	91	28	18	57
1984	6	3	9	9	5	14	8	5	25	17	14	39	25	18	50	23	11	20	24	16	60
Mean: 80-84	4	2	9	6	4	20	7	4	15	14	9	36	20	12	47	22	13	65	23	16	69
Mean: 51-84	3	2	6	6	3	14	6	4	14	12	7	27	18	12	45	19	13	55	19	13	54

Appendix 3. Physical characteristics of caribou from Spatsizi Wilderness Park, B.C. Measurements include total length along spine (T.L.); length of hind foot (H.F.) and ht. at shoulder (Shdr.), both with nail; length of antler main beam (* indicates broken antler). Under "calf" (status of females at capture), No* indicates female not specifically seen with a calf although calves were present in the group involved.

Animal Number	Date	Sex	Age[1]	Measurements (cm)									Antler Points		Calf
				T.L.	Tail	H.F.	Ear	Shdr.	Circ. Neck	Heart Girth	Antlers				
											L	R	L	R	
B02	10/24	F	12+	-	22	-	13	103	58	130	-	-	4	3	No
B03	10/26	F	2	189	15	-	10	113	49	138	30	35	3	4	No*
B04	10/26	F	YA	-	-	-	-	-	-	132	-	-	-	-	No*
B05	10/26	F	12	197	16	43	13	119	55	125	-	-	-	-	No*
A00	10/28	F	7	209	16	47	12	122	54	136	48	45	6	5	Yes
B07	10/28	F	AA	202	-	-	-	114	52	141	44	42	5	4	No
B08	10/28	F	YA	207	12	49	13	126	53	132	42	38	5	5	No
B09	10/29	F	5+	195	11	41	13	111	52	126	45	42	4	5	No*
B10	10/29	F	AA	198	15	40	14	110	54	125	42	44	4	3	No*
B11	10/30	F	YA	186	13	40	11	113	54	122	32	30	3	3	No*
B12	10/30	F	16	192	12	40	15	117	59	130	23	26	2	1	No*
B13	10/30	F	12	210	13	-	14	121	51	130	28	32	3	3	No*
B14	10/31	F	AA	206	15	41	16	137	61	132	41	43	5	5	No*
B15	10/31	F	-	-	-	-	-	-	-	-	-	-	-	-	No
B16	11/01	F	12+	208	14	44	14	125	60	142	44	45	7	3	No
B17	11/02	F	1	180	14	41	13	119	52	122	21	19	3	1	No
B18	11/02	F	9	219	-	44	16	134	59	144	45	51	6	4	No
B19	11/02	F	11	198	-	-	-	-	52	130	0	0	0	0	No
B20	11/03	F	10	190	15	41	14	122	54	125	36	36	5	5	No*
B21	11/04	F	3	205	14	41	15	117	55	129	47	40	3	1	No*
B22	11/05	F	12	-	17	38	15	-	65	-	66	66	11	9	No
B23	11/05	F	AA	212	16	43	15	127	55	136	45	43	5	4	No*
B24	11/06	F	YA	193	15	40	14	113	50	121	20	19	2	2	Yes
B25	11/07	F	18	193	16	42	16	129	58	140	48	47	5	6	No
dead	10/29	F	2	195	15	47	15	128	50	137	3	32	1	1	No
B27	10/27	M	YA	208	-	-	-	135	-	136	-	-	-	-	-
B28	10/31	M	8+	206	13	43	16	142	77	145	97	91	11	10	-
B29	10/31	M	2+	213	16	48	17	129	58	127	24	9*	3	3	-
B30	11/04	M	4	220	19	48	15	130	74	143	96	96	8	13	-
B31	10/28	M	9	221	14	50	14	138	74	152	104	100	9	10	-
B32	10/29	M	3	213	17	47	15	130	62	135	65	68	6	5	-
B33	11/05	M	7	219	18	46	-	138	79	143	0	0	0	0	-
B34	11/06	M	3	202	16	45	17	-	68	-	77	68	3	4	-
B35	11/06	M	2+	236	16	46	16	122	68	142	79	77	7	7	-
B36	11/02	M	5	228	17	45	14	141	79	145	94	101	12	16	-
B37	11/01	M	5	230	18	47	13	158	88	146	80	84	14	11	-

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[1] Numerical ages (years) from counts of cementum annuli (B.C. Wildlife Branch, Victoria); AA identifies animals believed at least 4 years old by tooth wear and other characteristics (see text); YA indicates "young adults", i.e., animals judged to be 2-3 years old by dentition and other features.

Appendix 4. Summary of radio-tracking histories for 39 caribou located 5 or more times in the Spatsizi Wilderness Park Area, British Columbia, 1980-84. The status indicated is as of Nov. 1984: A - alive and transmitting; D - dead; X - either dead or or lost collar; M - missing (signal not heard and animal not seen for 3 or more months); T - alive, but not transmitting.

Animal Number	Sex	Tracking Period	Potential Contacts		Satisfactory Contacts			Status
			Flt. No.s	N	No.	%	T[1]	
A00	F	11/80-11/84	1-59	54	48	89	52	A
A01	F	11/80-03/82	1-27	27	27	100	31	T
A02	F	11/80-11/84	1-59	54	45	83	48	A
A03	F	11/80-03/82	1-27	27	24	89	25	D
A04	F	11/80-11/84	1-59	54	41	76	47	A
A06	F	11/80-05/81	1-14	14	10	71	11	D
A07	F	11/80-02/82	1-24	24	19	79	20	D
A08	F	11/80-11/84	1-59	54	41	69	44	A
A14	M	11/80-02/82	1-24	24	23	96	24	M
A15	M	11/80-03/81	1-10	10	7	70	8	D
A16	M	11/80-03/82	1-27	27	23	85	24	D
B02	F	11/82-05/84	34-53	16	16	100	21	D
B03	F	11/82-11/84	34-59	21	21	100	27	A
B04	F	11/82-11/84	34-59	21	20	95	24	A
B07	F	11/82-11/84	34-59	21	19	90	23	A
B08	F	11/82-11/84	34-59	21	16	76	17	A
B09	F	11/82-11/84	34-59	21	21	100	25	A
B10	F	11/82-11/84	34-59	21	19	90	22	A
B11	F	11/82-11/84	34-59	21	20	95	23	A
B12	F	11/82-05/84	34-54	16	13	81	15	D
B13	F	11/82-05/84	34-54	16	15	94	19	D
B14	F	11/82-11/84	34-59	21	20	95	22	A
B15	F	11/82-11/84	34-59	21	20	95	22	A
B17	F	11/82-02/84	34-50	14	14	100	16	D
B18	F	11/82-11/84	34-59	21	20	95	25	A
B19	F	11/82-11/84	34-59	21	18	86	20	A
B20	F	11/82-11/84	34-59	21	18	86	21	A
B21	F	11/82-11/84	34-59	21	17	81	20	A
B23	F	11/82-03/84	34-51	15	15	100	17	D
B24	F	11/82-11/84	34-59	21	18	86	20	A
B29	M	11/82-11/84	34-59	21	15	71	17	A
B32	M	11/82-11/84	34-59	21	20	95	21	A
B34	M	11/82-04/83	34-41	7	7	100	8	X
B35	M	11/82-11/84	34-59	21	19	90	24	A
C38	F	06/83-11/84	45-59	11	8	73	11	A
C39	M	06/83-11/84	45-59	11	4	36	5	A
D40	F	03/84-11/84	53-59	6	6	100	9	A
D41	F	03/84-11/84	53-59	6	5	83	6	A
D42	F	03/84-11/84	53-59	6	4	67	5	A

Appendix 4 (continued, p. 2)

Animal Number	Sex	Tracking Period	Potential Contacts Flt. No.s	Potential Contacts N	Satisfactory Contacts No.	Satisfactory Contacts %	Satisfactory Contacts T	Status
Contact Totals:		Females		708	618	87.3	708	
		Males		142	118	83.1	131	
		Both		850	736	86.6	839	

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[1] Total includes capture locations, locations on incidental flights, and instances of more than one location on a particular tracking flight.

Appendix 5. Caribou radio-tracking success on 54 complete[1] tracking flights, Spatsizi Wilderness Park and and vicinity, British Columbia, 1980-84. The number of animals known alive and transmitting in the study area are indicated as "number present"; only records from animals with at least 5 contacts during the study period are included.

Flight		Number	Located		Seen	
Number	Date[2]	Present	No.	%	No.	%
1	22/11/80	11	9	82	4	44
2	28/11/80	11	10	91	5	50
3	06/12/80	11	8	73	3	38
4	22/12/80	11	6	55	1	17
5	02/01/81	11	10	91	4	40
6	15/01/81	11	10	91	3	30
7	29/01/81	11	9	82	6	67
8	16/02/81	11	10	91	3	30
9	28/02/81	11	9	82	7	78
10	17/03/81	11	10	91	7	70
11	29/03/81	10	8	80	3	38
12	16/04/81	10	8	80	5	63
13	03/05/81	10	9	90	2	22
14	20/05/81	10	10	100	0	0
15	30/05/81	9	5	56	1	20
16	09/06/81	9	7	78	3	43
17	18/06/81	9	8	89	3	38
18	26/06/81	9	8	89	6	75
19	24/07/81	9	7	78	1	14
20	30/08/81	9	7	78	6	86
21	08/10/81	9	8	89	6	75
22	12/10/81	9	9	100	7	78
23	16/12/81	9	6	67	5	83
24	06/02/82	9	8	89	2	25
25	24/02/82	7	6	86	1	17
26	03/03/82	7	6	86	4	67
27	16/03/82	7	7	100	3	43
28	10/05/82	4	4	100	1	25
29	07/06/82	4	4	100	1	25
30	30/06/82	4	4	100	4	100
31	31/08/82	4	3	75	2	67
32	27/09/82	4	3	75	3	100
33	25/10/82*	4	2	50	2	100
35	02/12/82	27	25	93	5	19
36	06/01/83*	27	25	93	8	32
37	31/01/83*	27	26	96	9	35
38	13/02/83*	27	27	100	6	22
39	28/02/83	27	27	100	3	11
40	22/03/83	27	26	96	0	0
41	12/04/83*	27	27	100	3	11
42	10/05/83*	26	26	100	7	27
43	31/05/83*	26	26	100	14	54
44	12/06/83*	26	26	100	26	100
46	28/07/83*	28	20	71	19	95
47	09/10/83*	28	20	71	16	80
48	22/11/83	28	23	82	18	78
50	21/02/84*	28	23	82	1	4
51	13/03/84*	27	24	89	1	4
53	07/05/84*	29	19	65	0	0
55	04/06/84*	26	19	73	4	21
56	12/06/84*	26	23	88	19	83
57	20/07/84*	26	22	85	20	87
58	05/10/84*	26	22	85	20	87
59	26/11/84*	26	22	85	21	95
Totals, All Flights:		850	736	87	335	46

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[1] Location data for one or more animals were obtained on a total of 59 flights, although only 54 of those were complete tracking flights, terminated when it was believed that no further success could be achieved under conditions pertaining. The five partial flights include No. 34, on which the primary objective was to check for mortality signals from newly collared animals, No's 45 and 49 which began as regular tracking flights but had to be aborted because of bad weather, No. 52 which was a helicopter survey producing only incidental observations of collared animals, and No. 54 which was transportation to a ground search for a collar on mortality mode.

[2] Dates marked by * are the first days of surveys which took two or more days to complete.

Appendix 6. Home ranges of radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-84. Total range is that calculated for all locations (N), telemetric and/or visual, over the total tracking history for each individual through November 1984. Annual range is for locations from November through October in the years indicated.

	Animal Number	No. Months Tracked	Total Range (km²)		Annual Ranges (km²) 1980 - 1981		1981 - 1982		1982 - 1983		1983 - 1984	
			N	Area	N	Area	N	Area	N	Area	N	Area
Females	A00	49	52	1010	18	331	10	377	14	768	10	409
	A01[1]	48	31	1319	24	1318	5	143	1	-	1	-
	A02	49	48	2625	21	827	8	1887	12	1169	7	459
	A03	17	25	1670	21	785	4	493	-	-	-	-
	A04	49	47	2483	18	1444	8	1265	10	180	11	204
	A06	6	11	862	11	862	-	-	-	-	-	-
	A07	16	20	919	20	919	-	-	-	-	-	-
	A08	49	44	4172	20	3320	8	124	10	170	6	470
	B02	18	21	3349	-	-	-	-	16	1496	5	379
	B03	24	27	1202	-	-	-	-	15	819	12	583
	B04	24	24	2464	-	-	-	-	13	2334	9	340
	B07	24	23	494	-	-	-	-	15	290	8	445
	B08	24	17	2348	-	-	-	-	12	1665	5	742
	B09	24	25	1284	-	-	-	-	15	1157	10	726
	B10	24	22	3064	-	-	-	-	12	1519	10	2467
	B11	24	23	4222	-	-	-	-	15	861	8	1604
	B12	16	15	1303	-	-	-	-	14	1178	1	-
	B13	18	19	904	-	-	-	-	14	535	5	92
	B14	24	22	2483	-	-	-	-	13	1205	9	1292
	B15	24	22	3040	-	-	-	-	14	1748	8	2170
	B17	15	16	4865	-	-	-	-	15	4865	1	-
	B18	24	25	11280	-	-	-	-	15	9941	10	1441
	B19	24	20	4863	-	-	-	-	13	1493	7	4851
	B20	20	21	5447	-	-	-	-	14	2822	7	3275
	B21	24	20	4510	-	-	-	-	14	3035	6	303
	B23	16	17	1429	-	-	-	-	14	983	3	454
	B24	24	20	2390	-	-	-	-	13	1739	7	1348
	C38	17	11	2420	-	-	-	-	-	-	9	1197
	D40	8	9	2768	-	-	-	-	-	-	9	2768
	D41	8	6	1094	-	-	-	-	-	-	6	1094
	D42	8	6	754	-	-	-	-	-	-	6	754
Males	A14	16	24	968	23	737	1	-	-	-	-	-
	A15	4	8	685	8	685	-	-	-	-	-	-
	A16	17	24	817	20	796	4	167	-	-	-	-
	B29	23	17	3102	-	-	-	-	13	2828	4	383
	B32	24	21	1453	-	-	-	-	14	1313	7	577
	B34	7	8	208	-	-	-	-	8	208	-	-
	B35	24	24	1999	-	-	-	-	14	634	10	924
	C39	17	5	142	-	-	-	-	2	-	3	76

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[1] Includes 3 visual locations after transmitter failure in March 1982: July 1983, July and Oct. 1984.

Appendix 7. Movements of radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-1984. Movements are st. line distances between locations of individuals on successive flights. The period over which the calculated movements occurred (days) is indicated under the column "time".

Month		Female Movements (km)							Male Movements (km)						
			Frequencies (%)							Frequencies (%)					
Year/Flt. No.	Time	N	1-5	5.1-15	15.1-25	>25	Mean	SD	N	1-5	5.1-15	15.1-25	>25	Mean	SD
November															
1980/01	25	7	0	57	43	0	12.8	5.8	3	67	33	0	0	5.0	1.2
1980/02	6	5	40	20	40	0	9.8	5.6	3	67	33	0	0	3.5	2.8
1983/48	43	17	6	53	11	30	23.7	22.8	2	50	0	0	50	19.8	24.8
1984/59	48	17	12	24	12	53	31.3	25.1	2	0	50	50	0	18.5	7.1
December															
1980/03	8	3	0	100	0	0	10.9	3.3	3	0	100	0	0	11.7	2.9
1980/04	16	4	0	0	25	75	32.9	7.7	1	0	0	0	100	29.6	-
1981/23	65	5	0	40	40	20	15.3	9.7	1	0	0	0	100	36.3	-
1982/35	25	20	5	35	25	35	23.8	16.3	5	0	60	0	40	25.5	18.6
January															
1981/05	11	5	20	60	0	20	18.0	19.7	1	100	0	0	0	3.6	-
1981/06	13	6	83	0	17	0	5.3	7.0	3	67	0	33	0	8.9	12.6
1981/07	13	6	0	100	0	0	7.9	3.2	2	100	0	0	0	2.2	0.3
1983/36	35	19	21	47	5	26	14.1	11.2	4	25	50	25	0	10.7	5.2
1983/37	23	20	45	30	15	10	10.2	10.4	4	0	50	50	0	16.7	6.7
1984/49	47	15	0	27	46	27	20.6	7.0	1	0	100	0	0	5.5	-
February															
1981/08	19	6	17	83	0	0	6.4	2.9	2	50	50	0	0	5.2	1.6
1981/09	12	7	29	71	0	0	6.8	2.5	2	100	0	0	0	2.4	0.5
1982/24	52	5	0	60	20	20	19.1	15.7	1	0	0	100	0	22.5	-
1982/25	18	4	0	25	75	0	10.4	14.2	1	100	0	0	0	2.1	-
1983/38	12	22	41	45	14	0	7.0	5.4	4	50	50	0	0	6.5	4.8
1983/39	15	23	57	30	9	4	6.9	7.1	4	25	75	0	0	7.0	2.9
1984/50	44	17	6	47	18	30	21.9	21.3	2	0	100	0	0	11.5	1.4
March															
1981/10	17	7	71	29	0	0	5.3	2.9	2	100	0	0	0	2.1	2.9
1981/11	12	6	50	17	33	0	9.9	8.8	2	50	50	0	0	6.2	8.4
1982/26	7	5	80	0	0	20	8.9	16.4	1	0	100	0	0	13.5	-
1982/27	13	5	40	60	0	0	6.0	4.0	1	0	100	0	0	5.4	-
1983/40	24	22	64	32	0	4	7.0	10.3	4	25	75	0	0	7.6	5.2
1984/51	21	19	21	63	5	11	14.1	19.7	2	50	0	50	0	8.5	10.1
1984/52	1-7	7	72	28	0	0	4.0	4.1	1	100	0	0	0	4.0	-
April															
1981/12	18	4	25	75	0	0	7.0	3.7	2	100	0	0	0	1.3	1.9
1983/41	21	22	50	36	14	0	7.9	6.5	4	25	50	25	0	10.3	5.7
May															
1981/13	17	6	33	33	33	0	10.6	7.4	2	0	50	50	0	12.2	6.5
1981/14	17	7	29	29	13	29	16.1	11.6	2	50	50	0	0	5.7	7.5
1981/15	10	3	0	33	0	67	25.2	13.6	2	50	0	50	0	8.7	11.9

Appendix 7 (continued, page 2)

Month		Female Movements (km)							Male Movements (km)						
			Frequencies (%)							Frequencies (%)					
Year/Flt. No.	Time	N	1-5	5.1-15	15.1-25	>25	Mean	SD	N	1-5	5.1-15	15.1-25	<25	Mean	SD
May (continued)															
1982/28	55	4	25	50	0	25	12.2	14.4	0	-	-	-	-	-	-
1983/42	29	23	13	17	17	52	31.9	24.8	3	0	0	67	33	37.3	30.9
1983/43	20	23	4	17	9	70	44.4	27.0	3	0	0	33	67	39.3	20.6
1984/53	52	17	5	18	24	53	29.6	22.6	1	100	0	0	0	4.0	-
June															
1981/16	9	2	50	0	50	0	10.1	9.8	2	100	0	0	0	2.7	3.2
1981/17	9	6	67	17	17	0	11.4	20.9	2	50	50	0	0	6.4	2.7
1981/18	8	6	67	17	17	0	6.2	8.6	2	50	50	0	0	5.9	1.2
1982/29	28	4	0	25	0	75	32.1	23.5	0	-	-	-	-	-	-
1982/30	23	4	25	50	0	25	12.7	14.0	0	-	-	-	-	-	-
1983/44	12	23	65	17	0	18	9.1	12.9	3	33	33	0	33	15.2	13.9
1984/55	29	11	0	9	9	82	51.3	23.5	1	0	0	0	100	27.4	-
1984/56	7	13	69	31	0	0	3.4	3.2	4	0	25	75	0	13.4	5.6
July															
1981/19	28	6	33	34	33	0	9.0	6.6	1	0	100	0	0	6.2	-
1983/46	28	16	25	25	12	38	20.2	15.5	3	33	33	0	33	21.3	28.0
1984/57	35	18	33	28	22	17	13.6	13.3	2	0	50	50	0	16.4	3.1
August															
1981/20	37	6	17	33	33	17	14.6	8.5	1	100	0	0	0	4.6	-
1982/31	62	3	0	67	33	0	10.1	5.0	0	-	-	-	-	-	-
September															
1982/32	27	3	33	67	0	0	10.7	6.4	0	-	-	-	-	-	-
October															
1981/21	39	6	0	67	33	0	13.0	8.1	1	0	100	0	0	11.4	-
1981/22	4	7	14	86	0	0	7.5	3.9	1	0	0	100	0	18.0	-
1983/47	72	16	6	25	25	44	24.4	20.3	1	0	0	0	100	25.1	-
1984/58	78	18	6	39	17	38	25.7	21.5	2	0	0	0	100	39.2	19.1

Appendix 8. Mean daily movements of radio-collared caribou in the Spatsizi area, 1980-84. Results shown were calculated by dividing mean movements between flights by number of days between flights (see Appendix 7). Results marked with * are for flight intervals of 10 days or less.

Month	Daily Movements (km)	
Day/Year	Females	Males
November		
22/80	0.5	0.2
28/80	1.6*	0.6*
22/83	0.6	0.5
26/84	0.7	0.4
December		
06/80	1.4*	1.5*
22/80	2.1	1.9
16/81	0.2	0.6
02/82	1.0	1.0
January		
02/81	1.6	0.3
15/81	0.4	0.7
29/81	0.6	0.2
06/83	0.4	0.3
31/83	0.4	0.7
08/84	0.4	0.1
February		
16/81	0.3	0.3
28/81	0.6	0.2
06/82	0.4	0.4
24/82	1.0	0.1
13/83	0.6	0.5
28/83	0.5	0.5
21/84	0.5	0.3
March		
17/81	0.3	0.1
29/81	0.8	0.5
03/82	1.3*	1.9*
16/82	0.5	0.4
22/83	0.3	0.3
13/84	0.7	0.4
April		
16/81	0.4	0.1
12/83	0.4	0.5
May		
03/81	0.6	0.7
20/81	0.9	0.3
30/81	2.5*	0.9*
10/82	0.2	-
10/83	1.1	1.3
31/83	2.2	2.0
07/84	0.6	0.1
June		
09/81	1.1*	0.3*
18/81	1.3*	0.7*
26/81	0.8*	0.7*
07/82	1.1	-
30/82	0.6	-
12/83	0.8	1.3
04/84	1.8	0.9
12/84	0.5*	1.9*
July		
24/81	0.3	0.2
28/83	0.7	0.8
20/84	0.4	0.5
August		
30/81	0.4	0.1
31/82	0.2	-
September		
27/82	0.4	-
October		
08/81	0.3	0.3
12/81	1.9*	4.5*
09/83	0.3	0.3
05/84	0.3	0.5

Appendix 9. Elevation of radio-collared caribou on 59 radio-tracking flights in the Spatsizi area, 1980-84. Data from two capture expeditions (Flight 00: 21-28 Oct. 1980; Flight 33: 25 Oct. - 7 Nov. 1982) are included. Most tracking flights after No. 33 took 2-3 days to complete; dates listed are the first day of each.

Flt. No.	Date	Elevation (m)							
		Females				Males			
		N	Range	Mean	SD	N	Range	Mean	SD
00	10/28/80	8	1650-1800	1694	49	3	1650-1700	1675	25
01	11/22/80	6	1345-1700	1518	138	3	1525-1700	1642	101
02	11/28/80	7	1250-1765	1466	181	3	1375-1700	1542	162
03	12/06/80	5	1375-1475	1420	41	3	1350-1575	1475	114
04	12/22/80	5	1375-1825	1540	217	1	1325	1325	-
05	01/02/81	7	1375-1825	1632	176	3	1500-1825	1617	181
06	01/15/81	7	1350-1850	1593	187	3	1525-1925	1717	201
07	01/29/81	7	1525-1975	1821	144	2	1675-1925	1800	177
08	02/16/81	7	1350-1825	1621	205	3	1225-1475	1308	144
09	02/28/81	7	1675-1825	1732	67	2	1525-1575	1550	35
10	03/17/81	7	1675-1875	1725	87	3	1200-1675	1392	250
11	03/29/81	6	1375-1875	1725	192	2	1200-1675	1438	336
12	04/16/81	6	1375-1975	1779	208	2	1375-1675	1525	212
13	05/03/81	7	1975-2125	1564	397	2	875-1225	1050	247
14	05/20/81	8	900-1325	1153	146	2	1175-1225	1200	35
15	05/30/81	3	1175-1375	1292	104	2	1225-1375	1300	106
16	06/09/81	5	1375-1875	1640	207	2	1225-1550	1388	230
17	06/18/81	6	1500-1975	1663	223	2	1025-1550	1288	371
18	06/26/81	6	1375-1825	1596	160	2	1550	1550	0
19	07/24/81	6	1525-1825	1650	110	1	1775	1775	-
20	08/30/81	6	1650-1750	1688	34	1	1725	1725	-
21	10/08/81	7	1075-1750	1632	246	1	1375	1375	-
22	10/12/81	7	1425-1750	1650	117	2	1525-1550	1538	18
23	12/16/81	5	1375-1575	1430	84	1	1375	1375	-
24	02/06/82	6	925-1825	1342	353	1	1850	1850	-
25	02/24/82	5	1225-1725	1345	217	1	1500	1500	-
26	03/03/82	5	1075-1675	1305	225	1	1225	1225	-
27	03/16/82	6	1025-1875	1400	357	1	1675	1675	-
28	05/10/82	4	950-1775	1194	394	0	-	-	-
29	06/07/82	4	1150-1825	1475	298	0	-	-	-
30	06/30/82	4	1375-1975	1750	260	0	-	-	-
31	08/31/82	3	1500-1750	1642	128	0	-	-	-
32	09/27/82	3	1500-1675	1600	90	0	-	-	-
33	10/ /82	25	1375-1900	1701	126	16	1575-1875	1714	83
34	11/04/82	2	1550-1700	1625	106	0	-	-	-
35	12/02/82	22	1075-1625	1382	175	5	1075-1475	1280	152
36	01/06/83	21	1225-1825	1364	139	4	1175-1375	1288	103
37	01/31/83	22	1025-1575	1320	124	4	1250-1350	1275	50
38	02/13/83	23	1175-1475	1327	89	4	1200-1500	1356	166
39	02/28/83	23	1100-1525	1305	112	4	1250-1400	1331	63
40	03/22/83	22	975-1425	1264	124	4	1250-1400	1331	63

Appendix 9 (continued, page 2)

Flt. No.	Date	Elevation (m)							
		Females				Males			
		N	Range	Mean	SD	N	Range	Mean	SD
41	04/12/83	23	1025-1525	1272	130	4	925-1250	1163	159
42	05/10.83	23	1025-1625	1303	140	3	1175-1400	1283	113
43	05/31/83	19	1325-1975	1746	167	3	1350-1375	1358	14
44	06/12/83	27	1175-2100	1724	248	4	1225-1675	1413	206
45	06/29/83	1	1625	1625	-	0	-	-	-
46	07/28/83	18	1375-2150	1758	181	3	1800-1825	1808	14
47	10/09/83	26	1225-1825	1638	146	2	1475-1675	1575	141
48	11/22/83	21	1325-1675	1575	97	2	1400-1525	1463	88
49	01/08/84	5	1175-1550	1370	170	1	1625	1625	-
50	02/21/84	21	1075-1650	1394	119	2	1400-1475	1438	53
51	03/13/84	22	975-1475	1288	120	2	1425-1475	1450	35
52	03/15/84	12	1100-1400	1308	84	1	1225	1225	-
53	05/07/84	18	1075-1650	1301	139	1	1225	1225	-
54	05/10/84	3	1125-1225	1183	52	0	-	-	-
55	06/04/84	15	1250-1825	1510	167	4	1050-1725	1406	288
56	06/12/84	20	1325-2150	1713	213	3	1100-1225	1175	66
57	07/20/84	22	1275-1950	1688	176	2	1625-1925	1775	212
58	10/05/84	29	1375-1875	1695	132	6	1425-1825	1638	130
59	11/26/84	20	1250-1800	1640	120	2	1425-1725	1575	212

Appendix 10. Direction of slope (aspect) occupied by radio-caribou in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984. The indicated slope direction is a 90° quadrant, e.g. north is the quadrant between northwest and northeast.

Aspect	Occurrences[1], All Years					
	Females		Males		Both Sexes	
	No.	Per Cent	No.	Per Cent	No.	Per Cent
North	362	52.0	84	59.6	446	53.3
South	253	36.4	42	29.8	295	35.2
East	131	18.8	22	15.6	153	18.3
West	121	17.4	28	19.9	149	17.8

[1] Total of 837 observations, including 696 for females and 141 for males; column sums exceed those figures because NW, NE, SW and SE were each used twice to define the 4 major quadrant totals.

Appendix 11. Habitats occupied by radio-collared female caribou during tracking flights in Spatsizi Wilderness Park and vicinity, British Columbia, 1980-84. N is the number of locations during the year indicated. The four habitat categories are distinguished as follows: Alpine - herbaceous or bare ground above 1700 m; Shrub - mostly arctic birch/willow and often with scattered small conifers, below 1700 m and usually adjacent to alpine; Forest - predominantly tree covered, mostly conifers; Other - bogs, river bars, meadows, burns, frozen lakes and rivers, all below timberline.

Month		Per Cent Occurrence in Habitats				Month		Per Cent Occurrence in Habitats			
Year	N	Alpine	Shrub	Forest	Other	Year	N	Alpine	Shrub	Forest	Other
November						May					
1980	13	23	38	15	23	1981	18	22	0	78	0
1981	0	-	-	-	-	1982	4	25	0	50	25
1982	14	57	43	0	0	1983	31	19	3	37	31
1983	21	0	95	5	0	1984	21	0	0	90	10
All	48	23	65	6	6	All	74	15	1	65	19
December						June					
1980	10	20	30	50	0	1981	17	47	24	24	5
1981	5	20	20	60	0	1982	8	50	25	25	0
1982	20	0	10	75	15	1983	38	61	5	21	13
1983	0	-	-	-	-	1984	33	42	3	48	6
All	35	5	17	66	9	All	96	51	9	31	8
January						July					
1981	21	57	0	43	0	1981	6	67	0	33	0
1982	0	-	-	-	-	1982	-	-	-	-	-
1983	25	4	0	88	8	1983	18	83	11	6	0
1984	5	0	20	80	0	1984	22	68	18	5	9
All	51	25	2	69	4	All	46	74	13	9	4
February						August					
1981	14	79	0	21	0	1981	6	83	17	0	0
1982	0	-	-	-	-	1982	3	67	33	0	0
1983	64	0	3	88	9	1983	0	-	-	-	-
1984	21	0	5	95	0	1984	0	-	-	-	-
All	99	11	3	80	6	All	9	78	22	0	0
March						September					
1981	13	92	0	8	0	1981	0	-	-	-	-
1982	11	27	0	73	0	1982	3	67	33	0	0
1983	22	0	0	91	9	1983	0	-	-	-	-
1984	34	0	6	91	3	1984	0	-	-	-	-
All	80	19	3	75	4	All	3	67	33	0	0
April						October					
1981	6	83	0	17	0	1981	13	85	0	15	0
1982	0	-	-	-	-	1982	11	82	18	0	0
1983	23	0	0	78	22	1983	26	27	62	11	0
1984	0	-	-	-	-	1984	27	52	33	15	0
All	29	17	0	66	17	All	77	53	35	12	0

Appendix 12. Observations of radio-collared female caribou at calving time, Spatsizi Wilderness Park and vicinity, British Columbia, 1980-1984.

The data below document the individual histories of 30 radio-collared caribou in terms of maternal status, habitat selection during the calving period, and calving success over the years of study. The data are based on results from annual surveys between mid-May and the end of June, with emphasis on the first two weeks of June. In most cases maternal status was determined by direct observation of the females during the surveys indicated, but occasionally by inference from contacts later in the year (see Table 16). Evidence of habitat selection at calving came from observations of females with very small calves and/or from records of occurrence of known or suspected parturient females in one location for several days during the calving period. Flight dates in 1983 were 31 May - 1 June and 12-14 June, i.e., at the start and end of calving, so actual calving sites are less certain for that year; data are given only for those instances in which there was little change between flights.

Maternal status: known (C) or suspected (S) to have had a calf; known (B) or suspected (W) barren, or status unknown (U).

Fate of Calves: SS - survived until at least October; L1 - known or suspected lost within a few days of birth; L2 - lost before end of July; L3 - lost between end of July and October; L4 - lost by October, but time not known; UU - unknown.

Calving Habitats: Cover - broad habitat category; Dist. - maximum distance (km) from location of previous year.

Animal Number Year	Maternal Status	Calf Fate	Habitat Selection During Calving				
			Elev.(m)	Aspect	Cover	Dist.	Comments
A00							
1981	S	L4	1825	S	alpine	-	Near head of Icebox Canyon.
1982	C	SS	1825	S	alpine	<1	Same area.
1983	C	L2	-	S	alpine	<1	Apparently same general area.
1984	C	L3	1975	S	alpine	<1	Bare knoll surrounded by snow; same area.
A01							
1981	C	L4	1375	SE	subalp.	-	Thick shrub under sparse spruce-fir.
A02							
1981	C	L2	1475	E	subalp.	-	Mostly shrub w/ scattered fir krummholz.
1982	S	L1	1600	NE	subalp.	7	Thick shrub at timberline.
1983	S	L1	-	-	subalp.	4	In same general area at start of calving period.
1984	C	L2[1]	1675	N	forest	8	Thick fir in narrow canyon.
A03							
1981	C	L4	1575	SW	forest	-	Thick patch of subalpine fir.
A04							
1981	C	SS	-	-	-	-	Calving site not found.
1982	W	-	1150	N	forest	-	Thick pine in Moose Flats area.
1983	B	-	1825	SE	alpine	36	Rocky alpine slope.
1984	B	-	1550	S	other	29	Wet meadow in subalpine area.
A07							
1981	C	SS	1875	E	alpine	-	Steep, rocky slope on Mt. Will.
A08							
1981	C	L3	-	-	-	-	Not found until 30 June; 1450 m, Tomias Plateau area.
1982	S	L1	1325	N	forest	49[2]	Thick spruce-fir.
1983	C	L2	1275	N	forest	50	Thick spruce-fir.
1984	C	L2[1]	1725	S	alpine	81	Grassy alpine plateau; calf 8-10 days old.

Appendix 12 (continued, page 2)

Animal Number Year	Maternal Status	Calf Fate	Habitat Selection During Calving				
			Elev.(m)	Aspect	Cover	Dist.	Comments
B02							
1983	C	L3	1825?	S	alpine	-	Steep alpine slope at start of calving period.
B03							
1983	W	-	1975	N	alpine	-	Snowpatch; w/ other animals at start of calving period.
1984	C	SS	1825	S	alpine	18	Head of alpine basin; calf about 1 week old.
B04							
1983	C	L2	-	-	-	-	Seen in alpine both flts, but had crossed valleys.
1984	S	L1	1825	S	alpine	40	Still w/ hard antlers, 1525 m in subalpine, on 14 June.
B07							
1983	C	L1	-	-	-	-	Thick subalpine fir on 1 June.
1984	C	SS	1725	N	alpine	3	Alpine basin, surrounded by snow.
B08							
1983	S	UU	1975	SE	alpine	-	Seen w/ other caribou on both flights.
1984	C	L4	1350	SE	forest	2	Thick subalpine fir.
B09							
1983	C	SS	1825?	S?	alpine	-	Steep alpine slope at start of calving period.
1984	C	SS	1625	S	forest	7	Thick patch of subalpine fir.
B10							
1983	C	L2	1950	N	alpine	-	High, narrow alpine ridge.
1984	B	-	1250	W	burn	9	Alone in Buckinghorse Valley.
B11							
1983	C	L2	1725	S	alpine	-	Just above shrub zone.
1984	B	-	1775	E	alpine	50	With another barren female.
B12							
1983	B	-	1625	S	other	-	Wet meadow below timberline.
B13							
1983	C	L4	1825?	W?	alpine	-	Rocky slope.
B14							
1983	C	UU	-	-	-	-	Seen in alpine both flights, but had crossed valleys.
1984	W	-	1500	S	forest	6	Krummholz on steep scree slope.
B15							
1983	C	L2	1675	S	forest	-	Thick fir on steep scree slope.
1984	S	L1	1525	S	forest	<1	Same area and habitat as previous year.
B17							
1983	B	-	1725	N	alpine	-	Alpine plateau.
B18							
1983	S	L1	1650	E	forest	-	Thick patch of subalpine fir.
1984	U	L2^{3}	1375	E	forest	4	Thick spruce w/ wet meadows nearby.
B19							
1983	S	L2	1725	N	alpine	-	Rocky alpine slope.
1984	C	SS	1725	SW	Alpine	5	Grassy alpine basin.
B20							
1983	C	UU	1425	NW	forest	-	Thick subalpine fir.
1984	C	SS	1325	SW	forest	1	Thick fir further down same creek as in previous year.

Appendix 12 (continued, page 3)

Animal Number Year	Maternal Status	Calf Fate	Habitat Selection During Calving				
			Elev.(m)	Aspect	Cover	Dist.	Comments
B21							
1983	C	L4	-	-	-	-	Seen in wet meadow below timberline on 12 June.
1984	U	L4[4]	-	-	-	-	Not located in June.
B23							
1983	C	SS	1725	S	subalp.	-	Thick shrub along headwaters of creek.
B24							
1983	W	-	-	-	-	-	Seen in subalpine fir area at start of calving.
1984	C	SS	2025?	E?	alpine?	9	Not located until 16 June; calf large.
C38							
1984	W	-	1500	NW	forest	-	Sparse fir with thick moss/lichen floor.
D40							
1984	C	SS	1550	SW	forest	-	Thick subalpine fir.
D41							
1984	C	SS	1500	NE	forest	-	Thick subalpine fir.
D42							
1984	C	SS	1700	E	alpine	-	Steep alpine slope.

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[1] Calf loss due to capture trauma.

[2] Distance from where 1981 calf first seen.

[3] If B18 had a calf in 1984, it was gone by July when she was first seen.

[4] If B21 had a calf in 1984, she had lost it by 26 November--the first time she was seen in that year.

Appendix 13. Investigations of known or suspected mortality among adult radio-collared caribou in the Spatsizi Wilderness Park area, British Columbia, 1980-84.

Following paragraphs list approximate death dates and lag-time to ground investigations, and describe evidence found at death sites for collared caribou which died from causes clearly not related to capture-induced injuries, illness or trauma.

In most cases causes of death could not be determined with certainty because too much time had elapsed and too little evidence remained. However, probable causes were assigned whenever possible. Some of the clues upon which assessments were based are as follows:

1) Nature of Remains: Three known wolf-killed caribou were examined. Nine wolves were found on the freshly killed carcass of female B22 the day after she was collared. Because they had not finished feeding, the nature of final remains could not be established, but by that time the carcass had been about one-half consumed, including the viscera, most flesh from the hind quarters and portions of the face and neck. One hind leg had been severed from the otherwise intact carcass, and the collar was still intact. Another collared female, B17, was apparently killed by a single wolf (see below), and the first items eaten were the nose and portions of the throat, viscera and one hind leg. Those two observations provide evidence only on the feeding pattern in terms of apparently preferred parts.

The only wolf-killed caribou examined after the wolves had finished was an uncollared animal of unknown sex or age. The fresh kill was seen from the air, mostly intact, on the afternoon of 6 March 1984, and was almost completely consumed when examined the following day. All that remained were stomach contents, scattered small patches of hide and hair, and a few bone fragments. Large bones, including the skull, had either been consumed or had been removed some distance from the site.

One apparently scavenged caribou was examined. On 26 February 1982, an old female was found frozen, still mostly intact, on the bank of the Spatsizi River near Hyland Post. A single wolf had visited the site and had eaten portions of the uppermost surfaces from hind leg to front shoulder. Some ribs were showing, but none had yet been broken and all viscera were frozen and still in the body cavity. No portion of the head or neck had been marked. The wolf apparently did not return after the examination, but a wolverine was seen there two days later. The site was visited again in early June, at which time the hide was found nearly intact, i.e., in one large piece, in a loose roll with the skin side out. It appeared to have been gradually rolled back. Most bones had been broken and partly consumed, but large joints, many vertebrae, the scapulae and portions of the skull were still present.

2) Fecal Remains: Droppings around kill sites were identified by the usual criteria -- diameter, shape, contents, etc., on the basis of the observer's experience. It was also noted whether droppings contained hair, indicating feeding when the prey was still intact, or contained primarily bony material, indicating meals made in the later stages of carcass utilization.

3) Condition of the Collar: It appeared that when carcasses were consumed by wolves, the collar was usually chewed and torn and was often removed from the kill site at least 10-20 m.

4) Other Sign: For recent kills, especially in snow cover, the identity of predators/scavengers was evident from tracks. Occasionally bits of hair were found snagged on objects such as tree trunks and branches.

Caribou Mortality Investigations, 1980-84

Animal No. A15: Male, 10 years old when captured in Oct. 1980; collars for that cohort (A-series) had no mortality sensors -- the last known or suspected movement was between 16 and 28 February 1981, and the animal presumably died between 28 Feb. and 17 March; site investigated 10 October 1981.

The kill site was on a relatively dry, timbered ridge at 1075 m, in an extensive muskeg area. The collar was found intact and unmarked on top of a thick pile of hair. There were several bones, including a large piece of the skull and one jaw, and large quantities of hair. The relatively concentrated remains suggested that the animal had died and had been scavenged primarily by small carnivores and birds. The suspected cause is "winter kill", influenced by old age and possibly also by an injury sustained during the rut. At capture that injury, a severe facial abscess, was treated by the capture crew (Hatler 1983).

Appendix 13 (continued, page 2)

Animal No. A06: Female, adult (4+ years, but exact age unknown); last movement detected on 3 May 1981, and animal apparently died between then and 20 May; site investigated 10 October 1981.

The collar was located in a mixed forest habitat 300 m from the edge of the Stikine River. It had been chewed up extensively, and had apparently been moved from the kill site since no animal parts could be found. The sparse evidence suggested that wolves had been present at least to the extent of damaging and moving the collar, and it was concluded that predation was possibly the cause of death.

Animal No. A07: Female, apparently old adult, but exact age unknown; last movement recorded on 16 December, and death apparently occurred between then and 6 February 1982; site investigated on 30 June 1982.

The kill was found near the east shore of Gladys Lake. A large quantity of hair, a large section of rolled-up hide and several bones, including both antlers, the skull and both jaws, were found within 10 m of the collar. The cheek teeth showed excessive wear. The collar had been sheared off in a single, remarkably straight-line cut, but there were few other marks. The most likely cause of death was age interacting with severe winter conditions (i.e., "winter kill"), and subsequent scavenging, mostly by a wolverine.

Animal No. A03: Female, adult of unknown age; not known to have moved after 16 March 1982, and probably died within about a week of that date; collar not reccvered until 14 June 1984.

The collar was located in a thick patch of subalpine fir at 1425 m. Despite the fact that over 2 years had gone by since the animal died, most bones were still present within a 30 m area. The intact (unchewed) collar was lying less than 10 cm from 5 intact, still articulated cervical vertebrae. Winter kill and subsequent scavenging by birds and mammals up to marten size seemed a certainty.

Animal No. A16: Male, 5 years old in October 1980; as with No. A03, no further movement after 16 March 1982 and death probably about at that time; site investigated 14 June 1984.

Only the collar was found, in a birch thicket beside a small lake at the base of Tsenaglode Mountain. It had been chewed open, but no hair or bone were seen. Predation could not be ruled out, but neither could winter kill, given findings for A03 and A07.

Animal No. B34: Male, age 3 years; mortality signal first heard on 11 May 1983; the signal came from a thickly wooded area far from the nearest potential landing spot, and the collar could not be recovered.

While the animal may be listed as a suspected mortality, the incidence of collar loss among other males suggests the possibility of that cause as well.

Animal No. B17: Female, age 1 year in October 1982; killed on 13 or 14 March 1984; site investigated on 15 March 1984.

The mortality signal was received on the morning of the 14th, indicating that the collar had been still for at least 6 hours at that time. On the morning of the 15th, the signal was back on live mode, indicating recent movement, and a small gray wolf was seen nearby.

The carcass was not frozen and was less than one-fourth consumed. The nose had been chewed off and the throat had been opened, but all feeding had been in the viscera and the inguinal region of the left hind leg. The bone marrow in both femur and humerus was pink/red and gelatinous, suggesting poor condition, but there was no outward manifestation of whatever might have been the problem.

The minimal consumption of the caribou carcass suggests that the kill had occurred on the night of the 13th, and that the mortality signal received on the morning of the 14th was the first cycle on that mode after the kill and first feeding. It appeared that the caribou had been surprised while feeding in tight quarters on bare ground under four close-together spruce. Patches of hair were found there and at two other spots within the 30 m between that location and the carcass. The cause of death was certainly predation, and there is no evidence that more than the one wolf had been involved.

Appendix 13 (continued, page 3)

Animal No. B23: Female, adult but exact age not known; mortality signal first detected on 7 May 1984, and death occurred between 13 March and that date -- probably later in that period because the animal was apparently enroute to her calving area when killed; site investigated 10 May 1984.

The kill site was in mixed forest at 1050 m, at the edge of a small creek about 400 m north of the BCR Grade in the Eaglenest Creek area. The grade had recently been opened to vehicular traffic as a result of work related to development of the Klappan coal fields. All that remained at the kill site was a patch of hair and two small bone fragments. The collar was intact with no tooth or other marks, and it had been carried or thrown about 25 m from the remains. No conclusive evidence for a cause-of-death determination was found. It was apparently either poaching or predation, but the facts were not entirely consistent with either. No obvious human sign was seen within 100 m of the kill, although there was a newly flagged trail from the grade to a small nearby lake, within 200 m of the killsite.

Animal No. B13: Female, age 14 years; last contacted on 7 May 1984, and probably died not long after although the mortality signal was not heard until 5 October; site investigated on 7 October.

The site of last live contact and the apparent area of death were only a few km apart, in the Marion Creek area. Since females usually disperse from that area in spring, an early May death is likely. The signal was tracked to the edge of Marion Creek, and found to be underwater; the collar could not be recovered. The signal was probably missed during the summer flights because it was farther upstream, in one of the deeper pools within a steep-walled canyon. The cause of death was not determinable, but an accidental fall from precipitous terrain in the area, an age related death, or predation are all reasonable possibilities.

Animal No. B12: Female, age 18 years; mortality signal first detected on 5 June; death apparently occurred in the approximately one month previous, since 8 May; site investigated 14 June 1984.

The kill was located in a thick spruce stand, with much blowdown, at 1025 m in a muskeg area. The carcass was among blowdown, and possibly the animal got entangled there while trying to escape. The only predator sign was bear -- about 12 large droppings in the immediate vicinity and others nearby, and a typical "raked up" area where the carcass had been temporarily buried. The collar had not been chewed and was within 10 m of the primary remains. The only skeletal material left were three lower leg bones, with digits. It appeared that much of the carcass had been dragged away in larger sections. That was partially confirmed by the presence of clumps of hair caught on the branches and bark of fallen trees at some distance from the main hair pile. A quick search of the general area within 100 m turned up nothing more except other bear droppings. An age-related death and scavenging by a grizzly bear seems the most likely diagnosis, but predation by the bear can not be ruled out.

Animal No. B02: Female, age 14+; as with B12, death occurred between the early May and early June 1984 tracking flights, probably early (pre-dispersal) in that period, since the death site was not far from the live location in May; site investigation on 14 June 1984.

The collar was found, intact and unmarked, at a kill site in a black spruce muskeg, 1075 m, near the mouth of the Ross River. Most of the animal had been eaten by a bear, although two bone-filled wolf droppings were also present. Many bones, including the skull, were still there and only minimally chewed. The animal probably died an age-related death and was then scavenged, mostly by a bear.

Appendix 14. The annual cycle of caribou in the Spatsizi Wilderness Park area, northern British Columbia.

Following paragraphs outline, in point form, the general activities, habitats, and aggregation tendencies applying to each of the major seasonal events depicted in Figure 17. They also indicate known differences in patterns due to differential predilections between classes of animals or differing environmental conditions, briefly consider the potential for inventory and capture of research animals during each period, and identify some major questions and data gaps still existing.

WINTER

For the caribou, winter is the longest season. In terms of activities and distribution, in some years it may begin earlier and/or end later than indicated in Fig. 17, depending upon snow cover characteristics.

Major Features:

- If snow is not excessive, animals are mostly dispersed in small groups in forested areas and shrub or meadow habitats below 1500 m, and are making mostly local movements.
- They may make long distance movements and/or concentrate on windswept alpine areas when lowland snow conditions are unsuitable.

Still Unclear:

- The sexes may segregate in at least early winter; males may wander more and remain higher at that time.

Inventory Potential:

- Poor during forest occurrence; when the animals are forced to use alpine habitats, possibilities for local total counts may be better than at any other time.

Aspects of Capture:

- Animals are least mobile, easiest to capture, and least likely to be injured when snow is deep.
- There is little likelihood of calf abandonment during winter captures.
- Animals captured in winter may move long distances in unpredictable directions to summer range, i.e., away from some local study area of interest.

SPRING MIGRATION

As with winter, commencement and termination may vary somewhat from the times indicated in Fig. 17, probably depending upon snow melt and phenology patterns.

Major Features:

- All animals are in lowland habitats in May; most males and at least some non-parous females continue to use those habitats through June; most migration occurs along valley bottoms.
- Parous females undertake fairly direct, rapid movements, completed by early June; groups are small.
- Other classes, especially males but possibly also some non-parous females, move later and more slowly.
- Calving occurs during the first half of June, while other classes are still migrating; females are greatly dispersed at that time.
- Post calving period: females with calves remain sedentary; most other females are moving and aggregating; at least some males are still moving from winter range.

Still Unclear:

- Do calves of the previous year travel to summer areas with their mothers?
- The early part of the spring migration period appears to be the time of most frequent mortality among adult females. Why? How?
- Are migration routes traditional for individuals?
- Are the movements of males and non-parous females as directed as those of parous females?

Inventory Potential:

- Very poor; not recommended.

Aspects of Capture:

- Not advisable in May (advanced pregnancies, unpredictable locations, thick cover).
- Locations in early June, particularly for parous females, are traditional; this may be the best time for capture in relatively small, local study areas.

Appendix 14 (continued, page 2)

- Animals are mobile and subject to injury (calves small, male antlers soft, ground hard); parous females can sometimes be herded to residual snow patches at high elevations.
- Risk of calf abandonment high if mother captured.
- For calf studies, early June captures are the most practical.

SUMMER

As shown in Fig. 17, there were relatively few radio-tracking observations in summer during the Spatsizi studies, therefore that season is the poorest known. Incidental observations during mountain goat surveys (Hatler and Hazelwood 1984, 1985) have provided useful supplementary information.

Major Features:

- Most individuals of both sexes are in alpine habitats, especially after mid-July.
- Both small and large groups present; females with calves usually stay solitary or join into small maternal bands, while the larger groups are mostly composed of males, non-parous females, and females which have lost calves.
- Females with calves move little through July, and some remain in the vicinity of calving locations throughout the summer and rut periods.

Still Unclear:

- Habitat use and the nature of movements is poorly known throughout this period, but especially in August and September.
- Group dynamics in summer are not well understood.
- Possibly females which calve farthest from the winter range may aggregate and move more than others (observations from Hatler and Hazelwood 1985).
- It is not known whether there is a period of specific and directed movement to rutting areas.

Inventory Potential:

- Animals are dispersed over a large area, but a high proportion are in habitats with little cover, thereby enhancing visibility; a sampling system might produce good data on total numbers and recruitment, and the best possible on sex composition among adults and proportion of young/mature animals among males.

Aspects of Capture:

- Animals are mobile and subject to injury from falls on hard ground, but are probably in their best condition in late summer.
- This is the best time for captures if studies focus on a particular summer range area.
- There is still some risk of calf abandonment if mothers are captured.

RUT

The actual peak of the rut and the extent to which that may vary from year to year has not been determined. There have usually been observations only over one or two days during that period in any one year.

Major Features:

- Numbers of animals are present above timberline in both large and small groups, although there are always at least some below timberline as well.
- Some areas are traditional in the sense that rutting groups appear there every fall, but not all animals are present; some female with calves are still in their calving areas.

Still Unclear:

- Group dynamics in relation to rut are poorly known; groups are known to split, join, and shift locations during the general period (Jones 1982, Hatler 1983, AIM 1982), but may be more cohesive and/or sedentary near the peak.
- Bulls may be under-represented on the main rut concentration areas both because some are tending outlier females and maternal bands, and because of frequent movements up and down slope (see Bergerud 1973).
- The rut may actually occur during and as a conspicuous feature of the fall migration, as for barren ground caribou in northern Alaska (Lent 1965). It has been argued that among migratory *Rangifer*, the movement may have a functional significance in breeding (Henshaw 1970).

Appendix 14. (continued, page 3)

Inventory Potential:

- Concentrations of animals occur in predictable locations; large samples may be obtained for composition analysis, but apparently biased against females with calves and possibly against males.
- An occurrence of a proportion of animals away from survey areas, probably varying from year to year, hampers interpretations of population numbers and trend (see Hatler, In Prep.).

Aspects of Capture:

- Generally the same pros and cons as for late summer (above).

FALL MIGRATION / EARLY WINTER

As noted above, the rut may be part of fall migration activities.

Major Features:

- Animals concentrate in a relatively small area, but apparently mostly in smaller local groups than occur during the rut; they are mostly in subalpine and alpine habitats after the main movement has occurred.
- As in spring, much of the movement appears to be along valley bottoms.
- Outliers during the rut, including females with calves, join other caribou groups.

Still Unclear:

- The timing of the early winter concentration and the extent to which the animals use upland habitats at that time may depend upon snow accumulation.
- Males may move separately and to different areas after the rut.

Inventory Potential:

- The distribution and concentration of animals, plus the return of successful mothers, suggests that large samples of relatively unbiased recruitment data could be obtained with minimal flying; males may be poorly represented, and possibilities for interpretations re numbers and trend may be no better than for the rut surveys.

Aspects of Capture:

- As for winter attempts, animals may disperse far from capture locations in other seasons, but snow conditions promote easier captures with less risk of injury than in other seasons.

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